December 1946

TECHNOLOGY REVIEW

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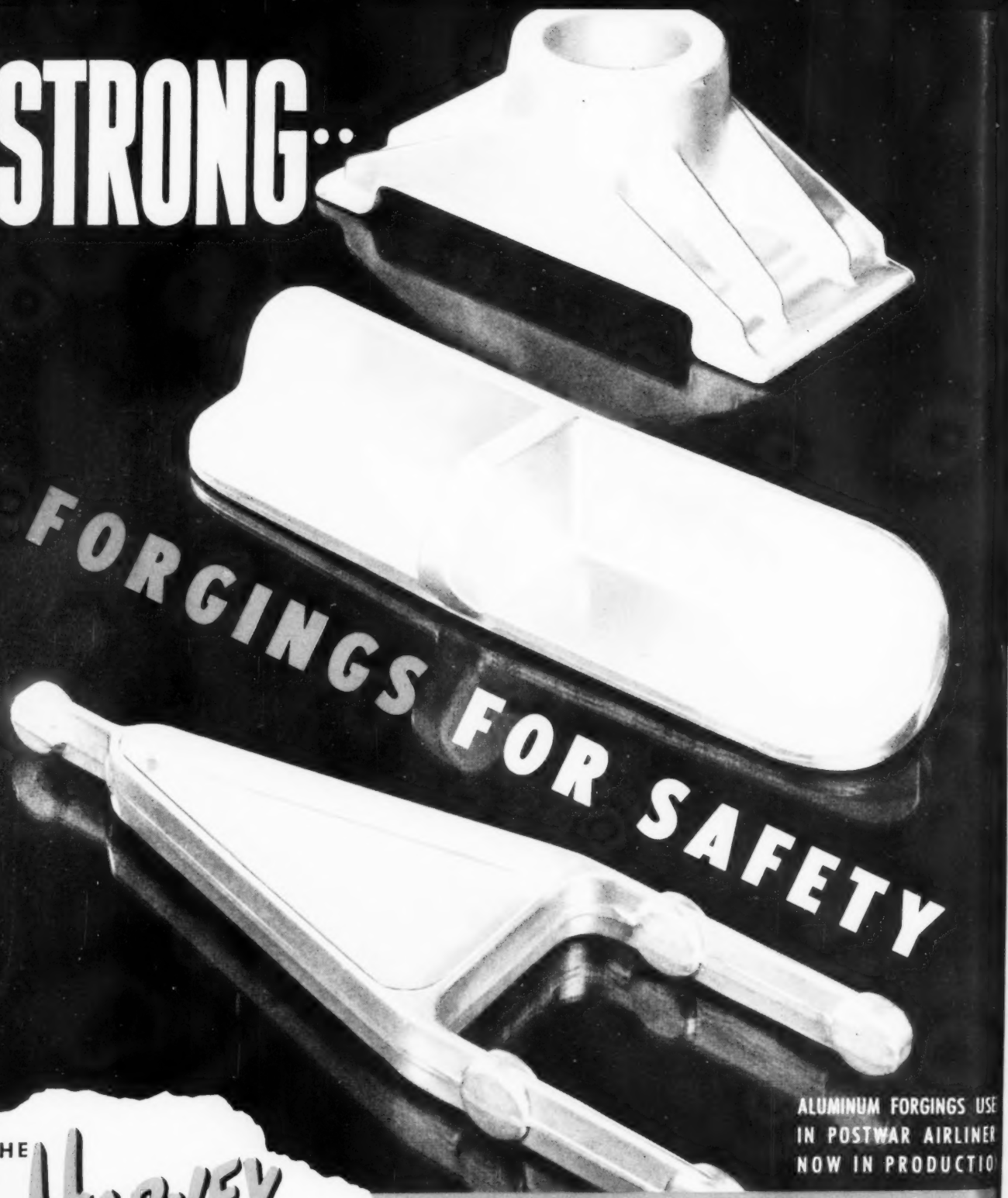

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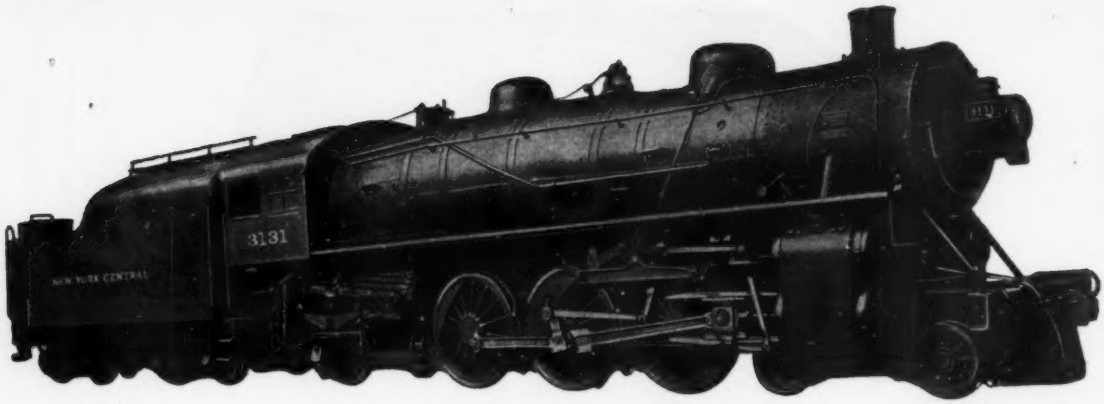
BRANCHES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, December, 1946. Vol. XLIX, No. 2. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.



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Old 3131 was a locomotive of destiny. Its boiler tubes were test tubes of progress. It was a laboratory on wheels . . . which contributed importantly to this century's greatest advance in the science of burning coal.

The story started in 1914. It was then that the Locomotive Pulverized Fuel Co., later to become part of the Combustion Engineering organization, began experiments with pulverized coal for firing locomotives. Instead of feeding coal by shovel, or stoker, the coal was first ground to a fine powder, then blown through a nozzle into the fire-box.

These experiments on "3131" and other locomotives indicated that stationary boilers might be more adaptable to the requirements of pulverized coal firing. Accordingly several trial applications were made. and one of these, completed in 1918, proved to be the turning point. It resulted in the building, two years later, of the world's first power station designed for the exclusive use of pulverized coal. Engineers journeyed from all over the world to see this plant and to observe the firing of its boilers with coal ground as fine as flour and burned in suspension like a gas. From then on the trend to pulverized coal firing was under way.

Among the immediate gains were larger and more efficient boilers capable of being operated at higher ratings, greater continuity of service, ability to use a wider range of coals and generally improved operating conditions.

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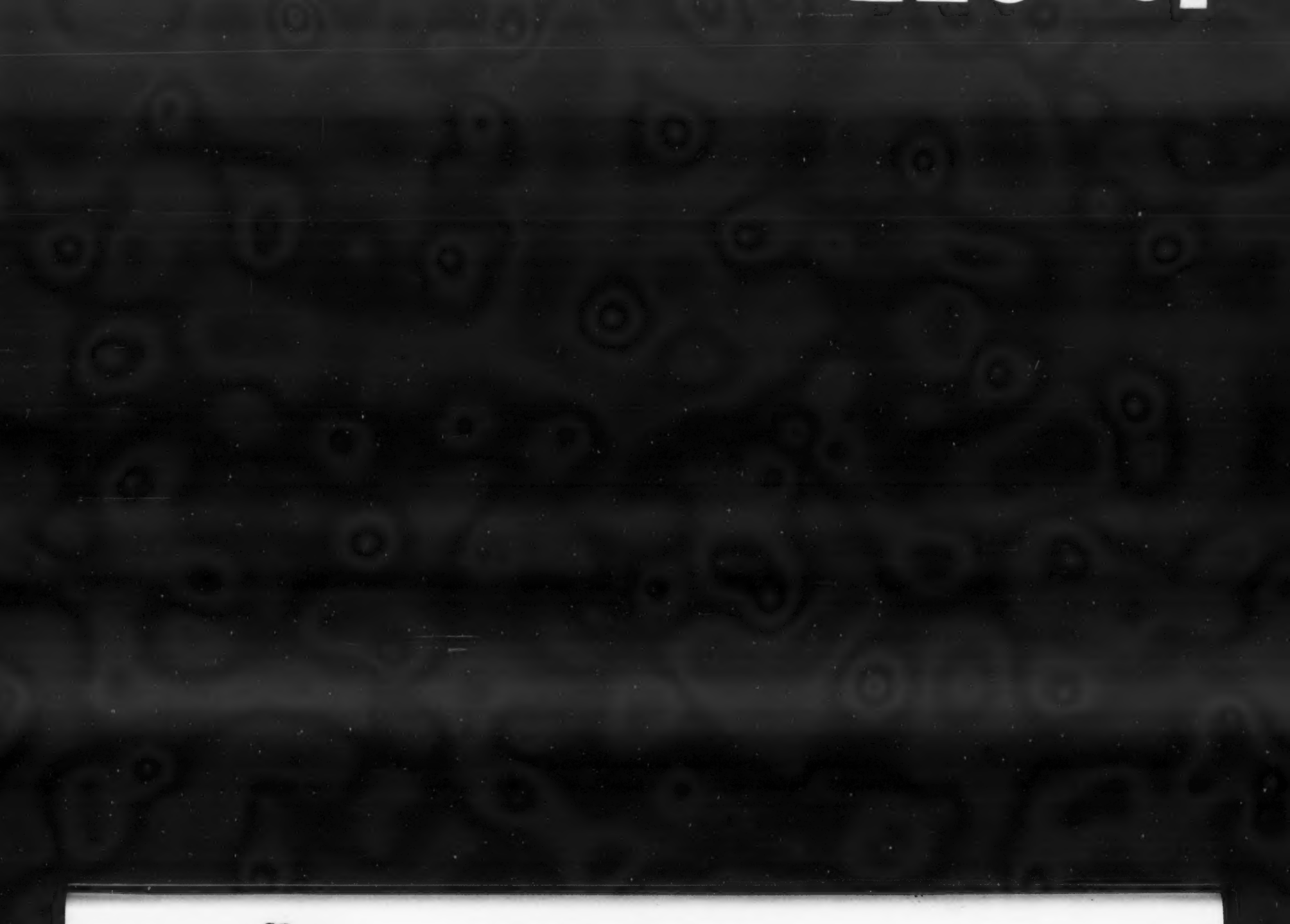

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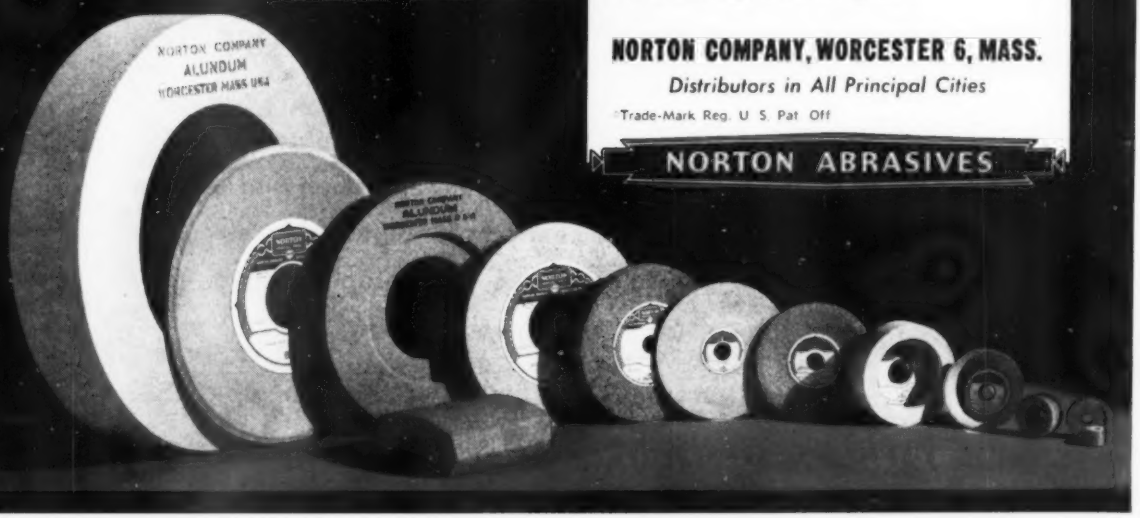

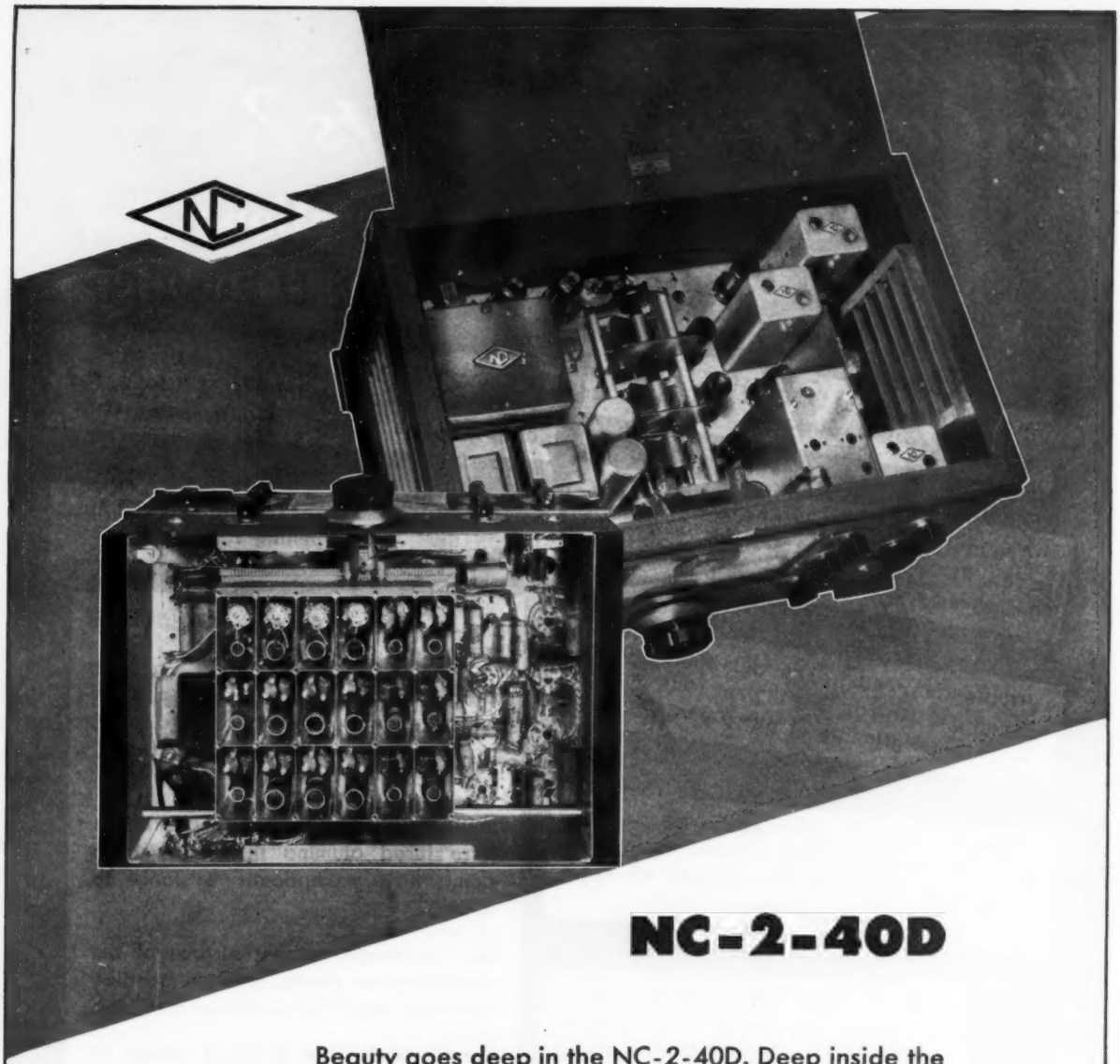

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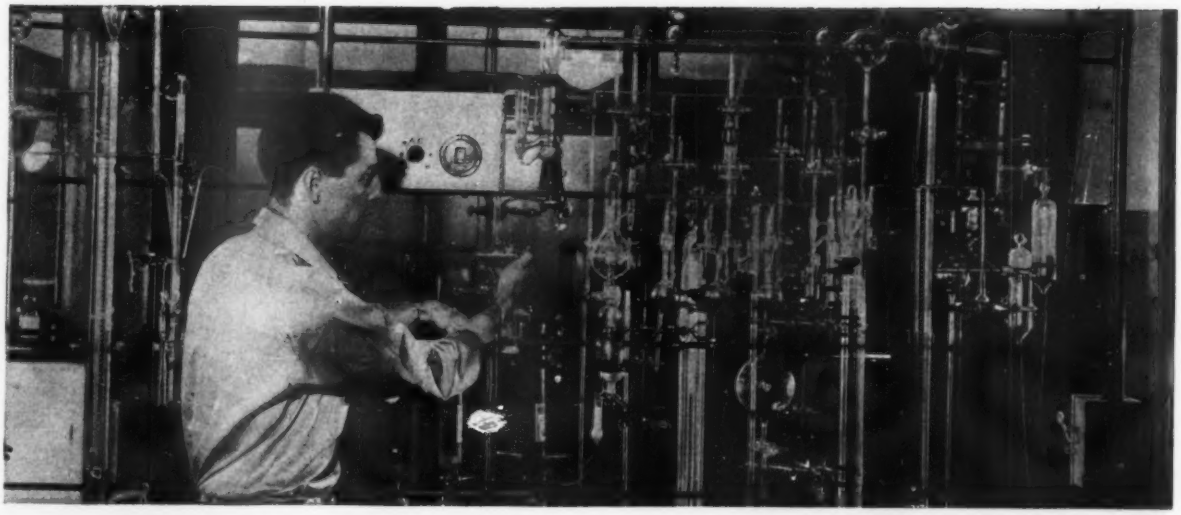

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For Industry, the Cabot Research and Development Department discovers new raw materials, new processes, and new applications. Above is an illustration. This is one of the many units in the Cabot research laboratories in Boston, assembled to study heats of adsorption with hydrocarbon gases.

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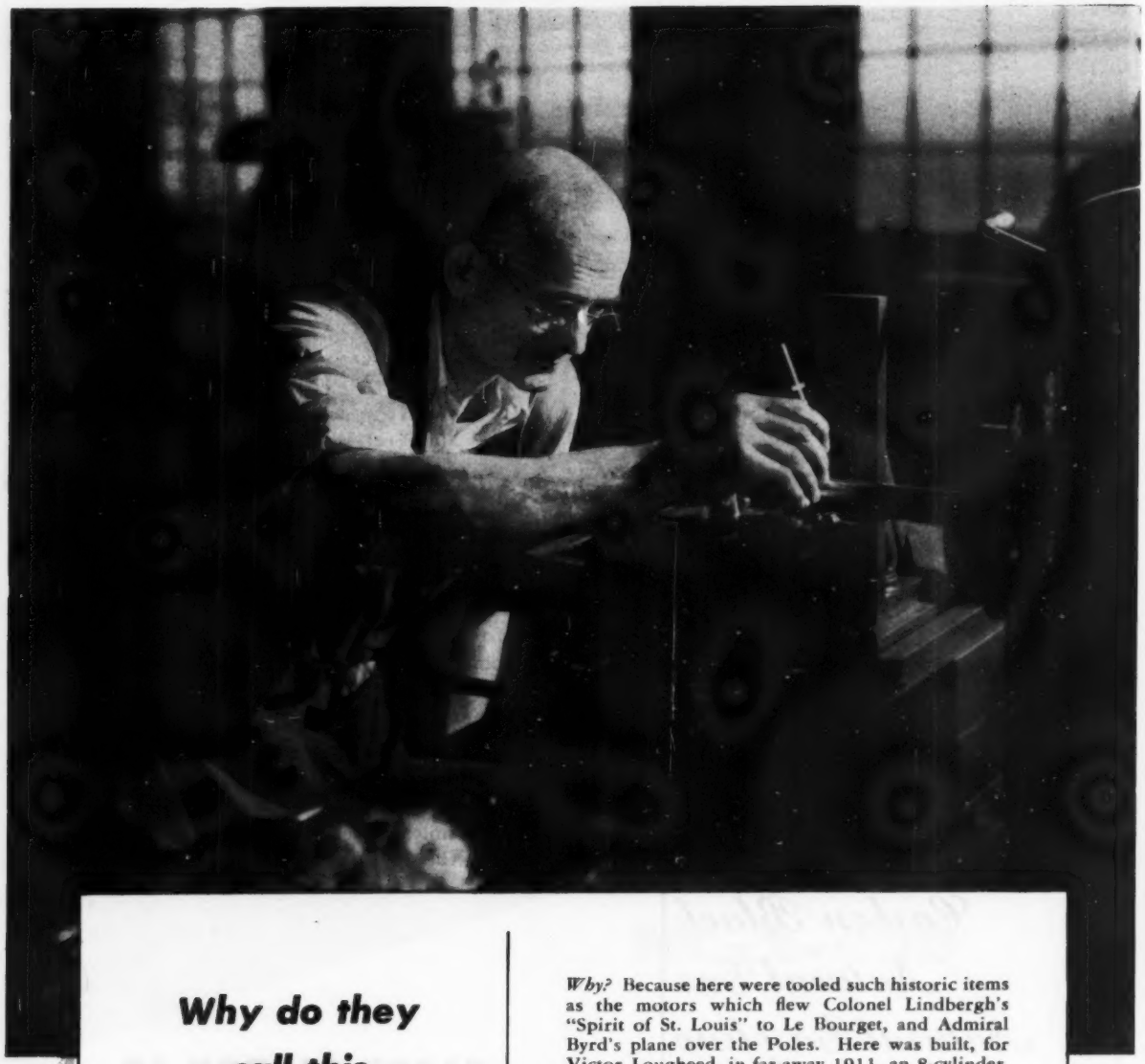

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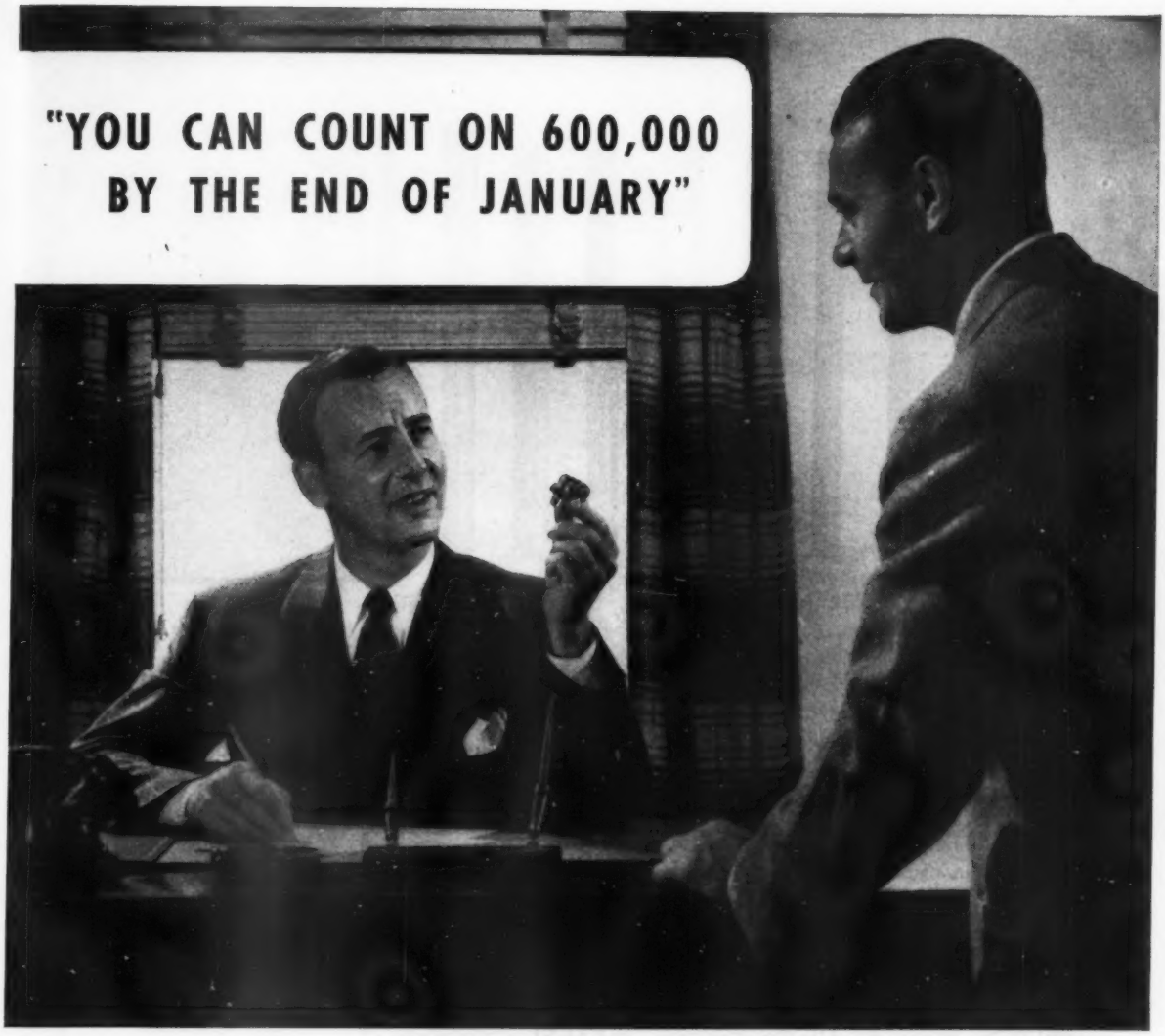

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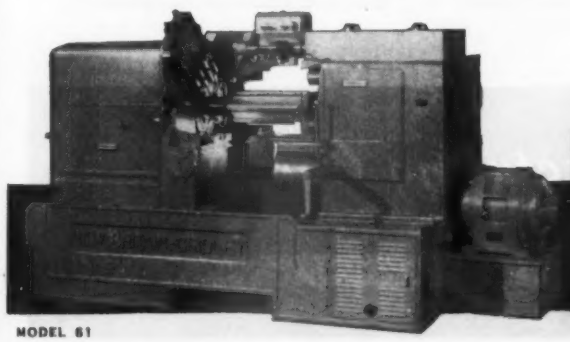

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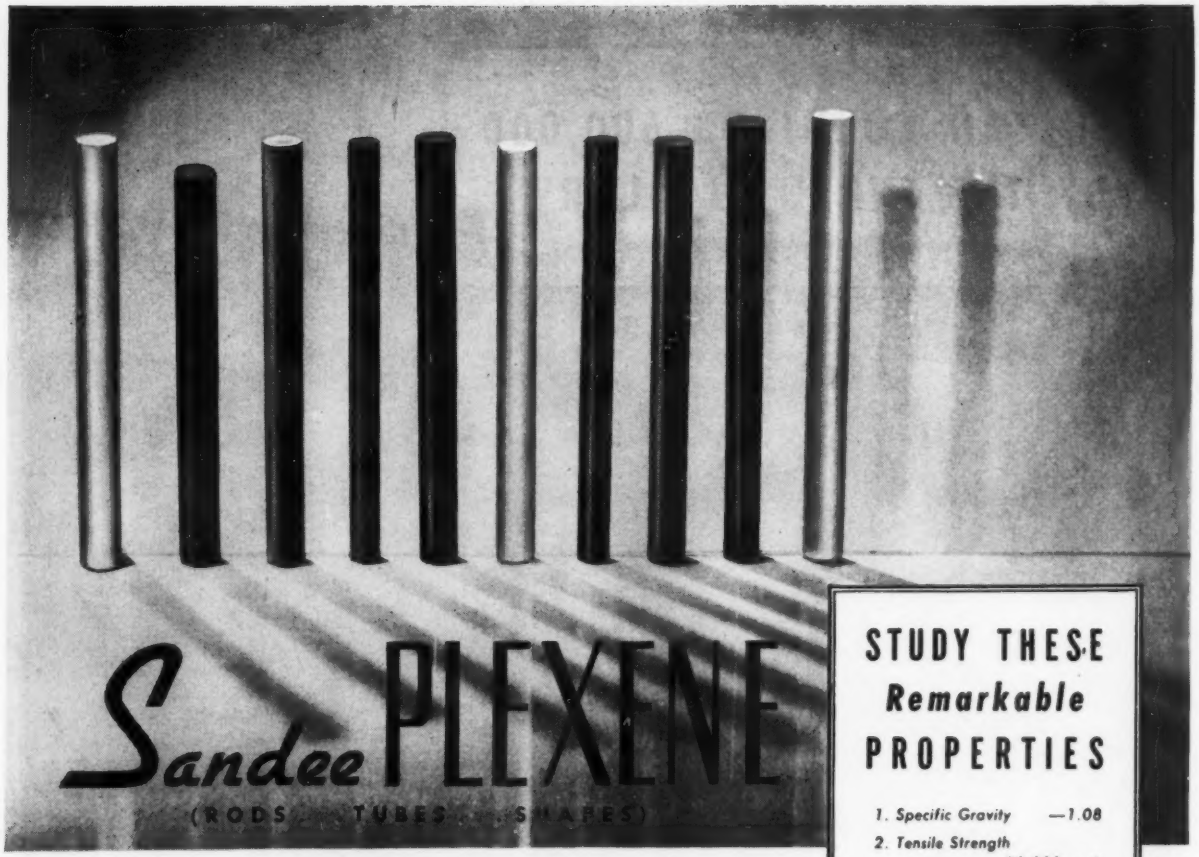

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ELMER SZANTAY, General Manager — '35

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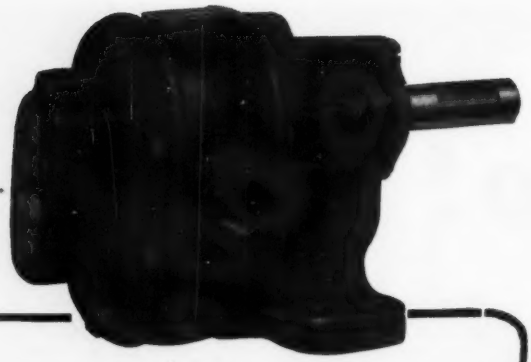

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A. B. ELLENWOOD, JR. '34

THE TABULAR VIEW

Union of Sciences.— Joining hands during the war in a program of research aimed to provide whole blood to the men of our armed forces, medicine and physics have accomplished results hardly possible without the close co-operation of these two sciences. The results of this program are recorded (page 91) by physician JOHN G. GIBSON, 2D, and physicist ROBLEY D. EVANS.

After graduation from Amherst College in 1919, Dr. Gibson served in the Field Artillery and then began a business career by attending the Harvard Business School from which he received an M.B.A. degree in 1921. For the next six years he was engaged as production manager in the manufacture of automotive parts, and in selling. Dr. Gibson then returned to Harvard and was graduated from the Harvard Medical School with an M.D. degree in 1932. Since 1933 he has been engaged in research on the measurement of circulating blood volume, one important aspect of which is recorded in this issue. Under a grant which it provided, the National Institute of Health, the Peter Bent Brigham Hospital, and the Harvard Medical School are continuing studies in this field under the direction of Dr. Gibson.

A native of Nebraska, Robley D. Evans attended the California Institute of Technology from which he received his bachelor's degree in 1928 and a doctorate in 1932. From 1929 to 1931 he was director of the research laboratory of C. F. Braun and Company of California, where he was engaged in chemical engineering research. During 1932 to 1934 he was a National Research Fellow in physics at the University of California in Berkeley, after which he came to M.I.T. as assistant professor of physics. He was advanced to associate professor in 1938 and to professor of physics in 1945. In 1937 he was awarded the Theobald Smith medal, an award in medical sciences which is administered by the American Association for the Advancement of Science, and given for the most important contribution to medicine made by an investigator less than 35 years of age.

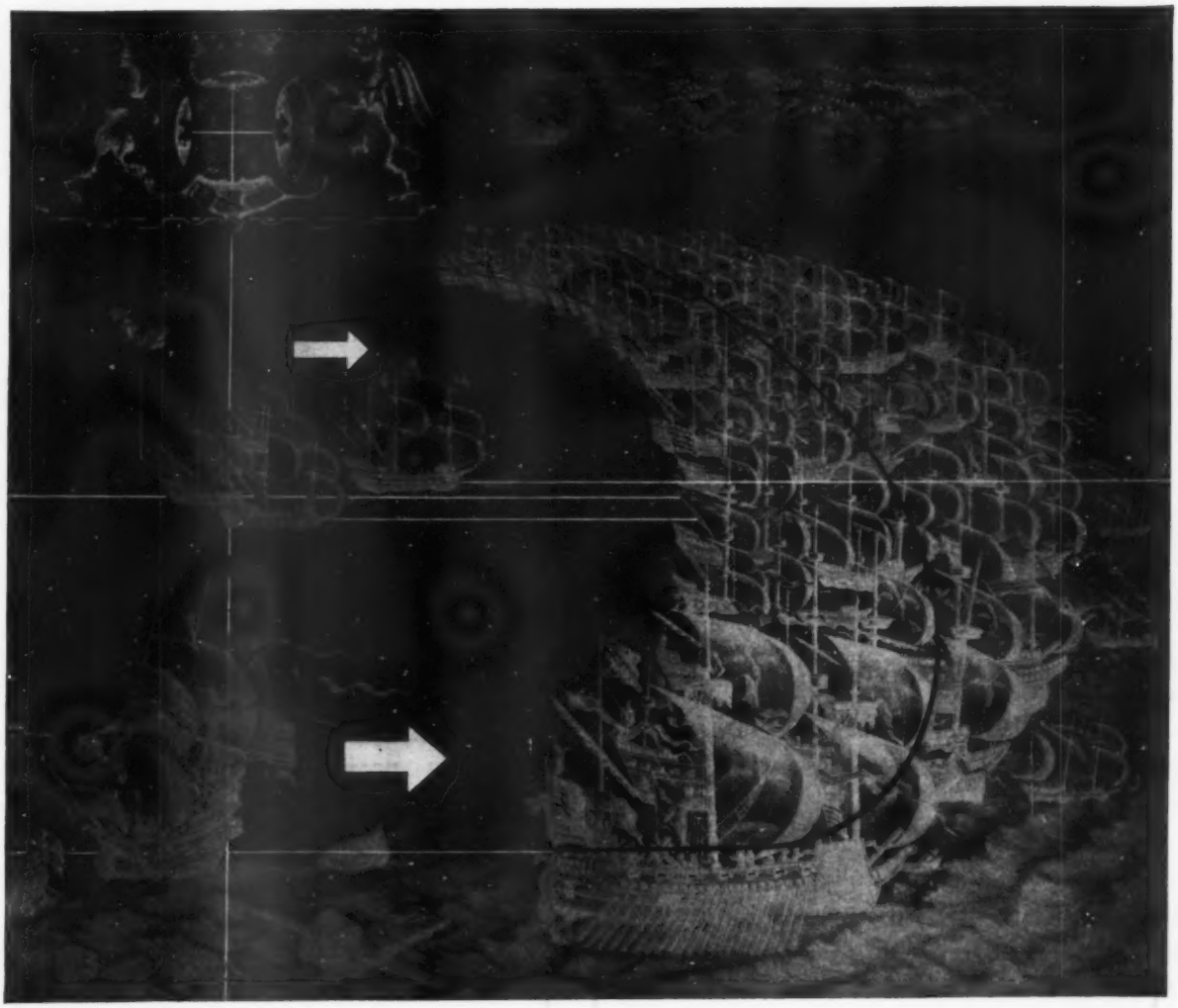
Rockets in Battle. — A long period of military use, marked by spasmodic successes and relative ineffectiveness, is the ancestry of the modern rocket. Brought to the public's attention during the war because of their grim military use, rockets and the historical development of these reaction-propelled missiles, as recounted (page 95) by WILLY LEY, take on added import. A research worker at the Washington Institute of Technology, Mr. Ley is well known to Review readers not only as one of its editorial associates, but also as a lecturer and frequent writer on current topics of technology.

Post-Industrialism. — Many factors already operating tend toward decentralization of our large cities, our industrial system, and many of our social institutions. Commenting upon these matters and recognizing that the industrialism which we know may hardly be the way of life for our descendants, PAUL MEADOWS directs thinking (page 101) to what may lie ahead. Dr. Meadows received his doctorate at Northwestern University and is assistant professor of sociology at Montana State University. His primary interests and writings deal with the human aspects of industrialization.

A LITTLE DOES A LOT

The Spanish built their colossal Armada to smother England by sheer weight. But Drake, with a scratch fleet of nondescript ships, and some brains, reduced the Armada to an unpleasant memory.

Not only in warfare can a little do a lot, intelligently applied. Today a little molybdenum is doing a lot to improve the strength and toughness of good cast iron. The foundry man's market is broadened and many a user's production headaches relieved. Practical working data is available on request.



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MAIL RETURNS

The Process Reversed

FROM FREDERICK ARPKE:

I felt that Dr. Meadows' article "The Industrial Way of Life" in the March issue of The Technology Review was excellent. Not only was it well written from a professional standpoint, but it was packed with suggestive ideas and altogether a most interesting thesis.

A really active drive for rural zoning has been under way in the Portland area and is receiving support from the most surprising places. However, this program represents only one small step in the right direction, and only emphasizes again the very crudeness of the tools that we are forced to use in modifying our social and institutional patterns to correspond with technical change.

Why shouldn't society set up the environmental standards that are considered to be desirable, and force our inventive technologists to adjust themselves to this pattern? As a matter of fact, there appears to be evidence that this is happening to some degree. The migration of certain industrial plants to smaller cities does not in any sense dispute the basic advantages of centralization, but rather represents an adjustment to a labor situation characteristic of large cities with which big business has found it difficult to cope. The few production "dis-economies" that might result from such a trend are certainly more than compensated for by the resulting social improvements.
Portland, Ore.

Technology and Community Development

FROM PETER F. DRUCKER:

I think Dr. Meadows' article an excellent presentation of a basic problem, but may I raise one minor point? It seems to me that in contrasting the disorganized industrial way of life with the traditional community life of the past, we are liable to overlook the point that the organization of the past was not innate in the technology of the preindustrial age but was created by man. In itself any system of production, or any technology, is abstract and impersonal and is not satisfying to man's basic personality. Community and social order are man-made, not material-made. I fail to see any reason why we could not develop a proper community in organizing the industrial way of life. This, however, does in no way mean that I believe we have such a community pattern or that its absence does not constitute a severe danger.
Bennington, Vt.

For the Good of Engineers

FROM WILBERT E. MOORE:

I thought "The Industrial Way of Life" a very good summary of the critical issues facing modern economies, and was especially happy to see it published in The Technology Review. It may do the engineers some good.
Princeton, N. J.

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—JAMES RUSSELL LOWELL

Why some things get better all the time

TAKE THE MODERN ELECTRIC LIGHT BULB, for example. Its parts were born in heat as high as 6,000° F. . . . in cold as low as 300° below zero . . . under crushing pressure as great as 3,000 pounds per square inch.

Only in these extremes of heat, cold and pressure did nature yield the metal tungsten for the shining filament . . . argon, the colorless gas that fills the bulb . . . and the plastic that permanently seals the glass to the metal stem. And it is because of such materials that light bulbs today are better than ever before.

The steady improvement of the electric light bulb is another instance of history repeating itself. For man has always had to have better materials before he could make better things.

Producing better materials for the use of industry and the benefit of mankind is the work of Union Carbide.

Basic knowledge and persistent research are required, particularly in the fields of science and engineering. Working with extremes of heat and cold, and with vacuums and great pressures, Units of UCC now separate or combine nearly one-half of the many elements of the earth.

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He flicks a switch and hushes a storm

ANOTHER REASON FOR GOODYEAR LEADERSHIP

STATIC is annoying enough on your home radio. But you can imagine what it means to a pilot who depends on good communications. Clearing up static can be a big step forward for the aviation industry.

Scientists at the Goodyear Research Laboratory went to work on the problem. They have developed a Static Limiter for use in planes, ships, two-way police radio sets—any place where long-range reception and transmission of signals are mighty important.

You simply flick a switch and—presto!—the static interference is practically gone. The Goodyear Static Limiter operates on any signal level or frequency. It cleans the noise pulses out, steps up the power of a weak signal and makes it possible to receive signals of better tone quality.

Development of the Static Limiter emphasizes again the vast variety and scope of Goodyear operations . . . men and women working in laboratories, factories and offices around the world—toward one objective: To make Goodyear products better today than they were yesterday, better tomorrow than they are today.

A pioneer in rubber and the world's leading builder of tires, Goodyear has also worked for years in metals, fabrics, chemicals, plastics, electronics and in many other vital fields . . . always seeking a better way to serve you.

GOODYEAR

THE GREATEST NAME IN RUBBER

Photo by H. Armstrong Roberts

"God rest ye, merry gentlemen!"

VOLUME 49 NUMBER 2

THE TECHNOLOGY REVIEW

TITLE REGISTERED U. S. PATENT OFFICE

EDITED

AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Photo by H. Armstrong Roberts

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"The old order changeth, yielding place to new"

☆ ☆ ☆

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"This house that I'll have in some far day"
Vagabond's House — Don Blanding

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The Trend of Affairs

For Tasteless Water

AN abundance of limpid, odorless, tasteless, and disease-free water is fundamental to modern civilization. And despite the public health axiom "a pure water supply is better than a purified water supply," increasing populations have so overtaxed available water sources that polluted sources must frequently be used, making purification treatment necessary. Chlorination, or addition of minute quantities of the element chlorine, is the standard method for killing disease germs in water, and also serves to destroy, by oxidation, certain of the odors and tastes commonly found in contaminated waters. However, a number of modern industrial processes produce wastes with high concentrations of phenols, and dispose of such wastes by discharging them into waterways. Phenolic wastes lend unpleasant tastes and odors to water containing them; furthermore, when such water is chlorinated, these tastes and odors, rather than being destroyed, are intensified by formation of compounds called "chlorophenols."

A new method for eliminating tastes and odors from waters, especially from those containing phenolic wastes, is use of the chlorine derivative chlorine dioxide. This compound has over twice the oxidizing power of chlorine. In addition, chlorine dioxide, rather than combining with phenolic wastes, destroys them. The potentialities of chlorine dioxide for taste and odor control were recognized long ago, but this compound previously could not be used in practical water treatment because its extreme instability prevents storage and shipment. However, when sodium chlorite became abundantly and inexpensively available not long ago, a method was perfected for generating chlorine dioxide in water treatment plants through reaction of sodium chlorite with chlorine, yielding chlorine dioxide and sodium chloride. The apparatus used is quite simple; continuous flows of solutions of the two reagents are mingled in a reaction chamber, and the effluent of this chamber is fed into the water mains. The sodium chloride so added, being stable, remains in the water, but this salt not only is innocuous but also is so minute in quantity as not to taste salty. The procedure followed is to chlorinate water first to accomplish disinfection, and then to apply chlorine dioxide for removal of tastes and odors.

Besides being effective against chlorophenols, chlorine dioxide also has proven useful to combat another troublesome source of tastes and odors — the algae or simple water plants that thrive in many reservoirs. Finally, chlorine dioxide aids in stabilizing concentration of residual chlorine in water mains. Such traces of chlorine are maintained in potable waters for the purpose of overcoming any infection that may gain access to the water between the time it leaves the treatment plant and the time it reaches the user. By completely destroying at the treatment plant all organic matter present in the water, chlorine dioxide prevents such organic material from later reducing residual chlorine by reacting slowly with chlorine in the water mains.

Pedagogically Speaking

THE huge enrollments which all colleges now face provide excellent opportunity, as well as a real need, to peer into the operations of the educational process, to re-examine the foundations upon which rests present-day teaching and to improve, wherever possible, the effectiveness of pedagogical methods. Such an examination is a continual process at the Institute as it is at all progressive educational institutions. Engineering education, in particular, is under constant scrutiny, for the sole aim of the American Society for Engineering Education is the betterment of pedagogy in the training of engineers. Harvard's "General Education in a Free Society" is also indication of the seriousness with which the general problem is being examined.

In spite of such constant and persistent efforts at continual improvement, there occasionally arises such a

clear-cut statement of objective analysis that it bears widespread dissemination. Such were some of the remarks made by A. A. Potter, '03, Dean of Engineering at Purdue University, at a symposium on engineering education held at Princeton University in celebration of that institution's bicentennial. "Teaching," says Dean Potter, "is an art, not a science. As an art, teaching is individual. The teacher is a member of an idealistic profession, and, like the artist or the musician, does his best work in an environment which is pleasant and which frees him from worries. The higher the rank of the teacher, the greater is his responsibility for true scholarship, and for the guidance of others."

In judging the effectiveness and ability of teachers Dean Potter places stress on the following points: (1) The teacher must know his subject thoroughly, thereby instilling confidence in his students; (2) Through mastery of the English language and by speaking so as to be easily heard and understood, the teacher must present his subject clearly and effectively; (3) He must have certain desirable traits of character and personality which command respect of his students, and, at the same time, inspire them and bring forth their best efforts; (4) His general education and cultural background must command the respect not only of his students, but also of his academic colleagues and neighbors.

A teacher must be, first of all, a person of character, so that he can instill sound character and appreciation of ethical standards in his students. It is not enough for him merely to purvey known facts about the strength of materials or an outline of organic chemistry; character development and preparation for good citizenship are major objectives of all education. It follows that an individual who has low ethical standards has no place in an educational institution. One who condones dishonesty, deceit or trickery, or one who evades the laws of the land, even in spirit, is not a good citizen; he can never be a good teacher. A teacher who lacks sincerity, who bluffs or exaggerates, is a detriment to any educational institution. His cleanliness, dependability, punctuality, accuracy, mental honesty, industriousness, conscientiousness, and his professional status and cultural attainments are easily detectable characteristics of a worthy addition to any faculty. Dress and appearance are other means by which a good teacher may be judged.

A teacher's self-control, optimism, and patience are other important indications of his effectiveness; so also are his clearness of exposition, his patience, his optimism, and his tact. An individual who is sarcastic, conceited, snobbish, profane, antagonistic, or, worst of all, one who is intolerant, is naturally precluded from being a good teacher. His attitude toward his students, his academic associates and superiors; the manner in which he speaks of the institution he serves and its policies also mark the teacher, to his benefit or detriment. Whether the individual is really interested in his work or whether he is merely a time-server also have an important bearing on a person's relations to his students and his employer.

Unbounded and contagious enthusiasm is an important characteristic of a good teacher. The great teacher radiates enthusiasm to those about him by the sparkle of his eyes or the vibrance of his voice. His students are fascinated by his general animation and by his interest in the subject he teaches. His enthusiasm does not have to be judged by visiting his classes.

Petroleum through Radioactivity

WHILE the original materials which form petroleum are generally agreed upon, the method by which these compounds were converted from the extremely complicated organic chemicals (present in the original living matter) into the relatively simpler compounds of petroleum is still a subject of much debate.

Most living matter, both animal and vegetable, is very complicated chemically and contains atoms of oxygen, nitrogen, and some small amounts of others, in addition to carbon and hydrogen. On the other hand, petroleum consists largely of carbon and hydrogen and any explanation of its formation must account for the elimination of the oxygen and other elements from the original material.

Recent research into possible mechanisms for this transformation has indicated that radioactive energy supplied by naturally radioactive materials may have been the cause of the change. By subjecting organic materials containing oxygen atoms in their make-up to the action of particles from the cyclotron beam or from a radioactive substance, such as radon, it has been found possible to remove the oxygen atoms from the larger molecule and transform it into a simpler hydrocarbon such as is found in petroleum.

Thus far the workers in this field have confined themselves to simple organic acids and have had considerable success in changing these compounds into hydrocarbons by removal of the oxygen in the form of carbon dioxide. The original compounds have been subjected to the action of radium emission and to the action of the beam from the cyclotron. The radium emission lends itself more readily to quantitative experiment but the greater amount of energy available from the cyclotrons has enabled them to process larger amounts of material and to achieve a conversion, from the original compound, of as high as three per cent. These conversion figures mean relatively little because a conversion of only one per cent of the organic matter in the earth around an oil pool is sufficient to account for all the oil present.

The work has now progressed to the point where it is planned to take samples of the earth from what is believed to be a potential oil pool, extract the organic matter from it, and subject this to the action of the cyclotron beam. None of this has yet been done but by reasoning from previous successful experiments there is every cause to believe that a substantial portion of the organic material will be converted into heavy hydrocarbons greatly resembling crude oil.

Speculation concerning this work leads immediately to the interesting possibility that a solution of this naturally occurring material might be used as a coolant in a uranium-plutonium pile and thus be subjected to radiant energy of a type and intensity sufficient to convert some of it into hydrocarbons. While this speculation is not necessarily idle it is far removed from actual fact. It is, however, an indication of the possibilities which may some day be achieved through large-scale exploitation of controlled atomic energy.

At present it is considered of more importance that this work lead to a greater knowledge of the mechanism of the formation of petroleum and by use of this knowledge enable man to search out existing deposits in a more intelligent and successful manner.

By John G. Gibson, 2d
and Robley D. Evans

Radioactive Blood Cells

Physics Aids Medical Research in War Program Leading to New Methods of Transporting, Storing, and Preserving Whole Blood

FOR the past 12 years, nuclear physicists have been able to produce in their laboratories a slow release of usable amounts of atomic energy by transmuting stable atoms of the ordinary chemical elements into artificially radioactive forms of the same or different elements. The atom-smashing experiments of the physicists, carried out in many laboratories throughout the world in a co-operative quest for a better understanding of nature, have produced a new scientific tool, artificial radioactivity, which already has found wide applications in all fields of science and technology.

Biologists and physicians quickly saw that many of their unsolved problems might yield to attack with this new tool. Physicists took time out from their studies of fundamental problems in nuclear physics to collaborate with workers in the life sciences in basic studies of the process of living. In the hands of these teams of scientific investigators in the physical and biological sciences, the use of artificial radioactivity has resulted in a series of medical discoveries and in the development of new therapeutic techniques which already during the war have saved many thousands of lives.

The use of atomic energy did not interest statesmen or congressional committees in the 1930's when these discoveries were being made. But the sober truth is that through medical advances alone, atomic energy has already saved more lives than were snuffed out at Hiroshima and Nagasaki.

One example of a co-operative team attack by physicists, physicians, and radiochemists is in the application of radioactive iron to fundamental studies of the behavior of human red blood cells, and to the war-medical problem of preserving whole blood during and after shipment half way around the earth. This work could not possibly have been concluded successfully by physicists alone, or by physicians alone, but by intimate co-operation between workers in several widely different fields of science, results of fundamental importance in medicine were quickly achieved. In developing and applying the physical methods, physicists found solutions to several problems in pure nuclear physics as well.

The modern era of blood transfusions was ushered in by the discovery of human blood-cell groups at about the turn of the century. This made it possible to select donors whose cells were compatible with the blood of the patient, without danger of reactions. The methods used were direct methods, that is, the blood was transferred directly by various means from the donor into the recipient's blood vessels, without the use of an anticoagulant. Blood transfusion was a surgical procedure requiring trained teams and careful attention to asepsis. The introduction of the use of sodium citrate as an anticoagulant in 1915 avoided the hazards of clotting in the interval between drawing and administering blood, and yet permitted the observance of aseptic precautions.

Blood Preservation of Recent Origin

The first successful preservation of human whole blood was accomplished in 1916 by Rous and Turner [1] by the addition of dextrose to the sodium citrate anticoagulant. This solution was used to a limited extent in World War I by Robertson,[2] but during the interval between the two world wars, the majority of blood transfusions given in this country and in England were of freshly drawn, citrated blood. It was not until 1937, with the advent of economical mechanical refrigerators, that the first blood bank was established in this country. Blood was taken in simple citrate solution, and was kept for only a few days. Interest in better blood preservation than could be obtained with citrate solutions was awakened in the years immediately preceding World War II, and greatly accelerated by the actual advent of hostilities. As casualties in the Mediterranean Theater mounted, it became obvious to the commanding medical officers that plasma, which had been relied upon entirely for the replacement of lost blood, could not replace lost red cells. Whole blood was necessary for the prevention and treatment of shock, since all wounded men suffer varying degrees of external or internal hemorrhage. During the early days of fighting the practice had been to obtain blood from donors in rear echelons for treatment of troops in base hospitals or for advanced

About 63 per cent of the Pacific casualties (more than 100,000 persons) received blood furnished by donors in the United States and supplied under the program reported in this article. The dating period was 21 days, but in routine use at Guam the Navy found it possible to use blood up to 28 days for military casualties, and for as much as 35 to 40 days for civilian cases in the Philippines. Such practice is not followed except under unusual cases, but the Navy's experience illustrates the success of the program conducted by members of the Committee on Medical Research, Office of Scientific Research and Development. It also illustrates the benefits which may accrue when two branches of science join hands in co-operation to meet man's needs.

[1] Rous, P., and Turner, J. R. "The Preservation of Living Red Blood Cells in Vitro," *Journal of Experimental Medicine*, 23:219 (1916).

[2] Robertson, O. H. "Transfusion with Preserved Red Blood Cells," *British Medical Journal*, 1:691 (1918).

hospitals. This constituted an unnecessary and sometimes dangerous drain on the health of supporting personnel. Furthermore, it did not seem possible that the increasing demands could be met from the civilian population in the British Isles.

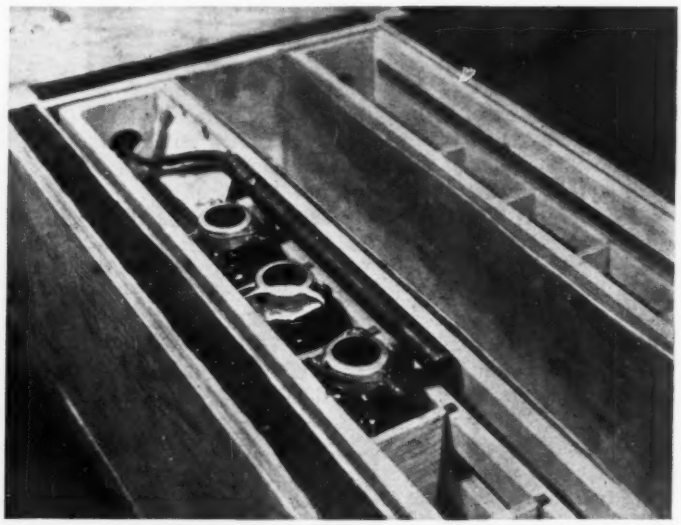
The obvious large source of whole blood was the United States, but to obtain this blood required transportation across the Atlantic. This, in turn, necessitated preservation for a period of at least three weeks, in view of the uncertainties of transportation and the delay incident to distribution to front areas.

Among the earliest workers in America in the field of blood preservation was DeGowin,[3] of the University of Iowa. This worker modified the original Rous-Turner solution, and observed clinically that the addition of dextrose to sodium citrate prolonged preservation considerably. Subsequent work by British workers, Loutit, Mollison, and Young,[4] had revealed the fact that acidification of the solution by means of citric acid further improved blood preservation.

While the beneficial effects of dextrose and acidification were recognized, the necessary facts upon which to base a military overseas blood program were, in the main, not known in 1940. The rate at which cells deteriorated during storage, even in the best solutions, had not been satisfactorily determined. The rate at which these deteriorated cells broke down in the recipient was not known, and the degree of hemoglobinemia to be expected following a transfusion of blood of a given age was a matter of conjecture. The ability of the individual to handle large amounts of plasma hemoglobin was an uncertainty, although the association of hemoglobinuria and renal damage was recognized. There was no knowledge of the degree of normal functional activity retained by those cells not rapidly eliminated after transfusion, nor to what extent the blood-building substances of the destroyed cells would be reutilized. The effect of mechanical agitation incident to transportation on survival of cells was unknown. Refrigeration was considered necessary, but optimal storage temperatures had not been determined. The extent to which cells would remain viable in any solution for a given time under conditions of transportation and refrigeration was unknown. And finally, no one could say just how a normal, or more important, a seriously wounded human, could withstand an improper transfusion. Therefore, the standards of acceptable transfusion of stored blood or the maximum safe period of storage could not be defined.

Numerous *in vitro* tests had been applied to the study of blood preservatives. Changes in osmotic fragility of the stored red cells, changes in the cellular dimensions, and the rate of hemolysis of cells during storage, had all been measured. There was, however, no general agreement that these observed *in vitro* characteristics bore any relation to the extent to which these changes were reversible when the cells were returned to the blood stream. It therefore became necessary to make direct *in vivo* measurements of the post-transfusion survival of stored human erythrocytes.

Such direct studies had been made by the agglutination test of Ashby.[5] In this method, Group O cells are administered to a Group A recipient. A sample of the recipient's blood is then treated with anti-A or anti-B sera, which agglutinates the recipient's A cells. The residual unagglutinated O cells are then counted by the ordinary blood-counting techniques, and the percentage of transfused cells which survive after transfusion is thus directly measured. The technique is laborious, and there are several inherent sources of error.



Temperature-sensitive element of the recording thermometer fixed in position in proximity to bottles of whole blood for aerial transportation. Note the dioxane indicators fastened to the bottle necks.

Radioactive Iron Traces Blood Cells

Since early in the course of the war, a group of physicians at the Harvard Medical School, and physicists of the Department of Physics at M.I.T. had been working under contract with the Office of Scientific Research and Development, conducting experiments to follow the course of the blood volume in experimental and clinical shock. The techniques employed utilized two radioactive isotopes of iron, and were based on the observation of Hahn[6] that, when intravenous radioactive iron is

[3] DeGowin, E. L., Harris, J. E., and Plass, E. D. "Studies on Preserved Human Blood. I. Various Factors Influencing Hemolysis," *Journal of the American Medical Association*, 114:850 (1940); "II. Diffusion of Potassium from the Erythrocytes during Storage," *Journal of the American Medical Association*, 114:855 (1940).

DeGowin, E. L., Harris, J. E., Bell, J., and Hardin, R. C. "Osmotic Changes in Erythrocytes of Human Blood during Storage," *Proceedings of the Society of Experimental Biology and Medicine*, 49:484 (1942).

DeGowin, E. L., Hardin, R. C., and Swanson, L. W. "Studies on Preserved Human Blood. IV. Transfusion of Cold Blood into Man," *Journal of the American Medical Association*, 14:859 (1940).

DeGowin, E. L., and Hardin, R. C. "Studies on Preserved Human Blood. VI. Reactions from Transfusion," *Journal of the American Medical Association*, 115:895 (1940).

[4] Loutit, J. F., Mollison, P. L., and Young, I. M. "Citric Acid-Sodium Citrate-Glucose Mixtures for Blood Storage; Report to Medical Research Council from Southwest London Blood Supply Depot," *Quarterly Journal of Experimental Physiology*, 32:188 (1943).

[5] Ashby, W. "The Determination of the Length of Life of Transfused Blood Corpuscles in Man," *Journal of Experimental Medicine* 29:267 (1919).

[6] Hahn, P. F., Ross, J. F., Bale, W. F., and Balfour, W. M. "Red Cell and Plasma Volume (Circulating and Total) as Determined by Radio Iron and by Dye," *Journal of Experimental Medicine*, 75:221 (1942).

administered to a donor subject, the iron becomes incorporated in the hemoglobin molecule as it is synthesized within the developing red cells. As these cells mature and are delivered to the circulating blood stream, their presence may be detected as long as those cells remain intact within the circulation. Thus, these tagged cells could be injected into a recipient, and if they were perfectly preserved, their observed dilution would serve as a basis for measuring the recipient's circulating red-cell volume. It soon became apparent that in addition to measuring red-cell volume, the method easily could be adapted to the measurement of the actual survival of the transfused cells themselves.

A radioactive form of iron, Fe^{59}, emitting beta rays and having a half period of 47 days, is formed by the transmutation of cobalt metal through neutron bombardment. In the course of this work a new radioactive isotope of iron, Fe^{55}, was produced by the transmutation of manganese through deuteron bombardment. This new isotope has a half period of about five years, and in its radioactive decay the atomic nucleus of Fe^{55} captures one of its orbital atomic electrons to form a stable atom of manganese. This radioactive transition gives rise only to the emission of the soft characteristic x-radiation of manganese, whose energy of only 5.9 kilovolts gives it very little penetrating power and renders detection difficult.

Rugged refrigerators were required to assure the safe transportation of whole blood by air. How well the experimental model survived the round trip between Boston, Mass. and Oakland, Calif. is shown here.

New types of Geiger-Müller counters were developed, to afford optimum detection sensitivity for Fe^{55} and at the same time to give substantially no response to the beta rays of Fe^{59}. Conversely, other counters were developed which respond only to Fe^{59}, and not to Fe^{55}. These new instruments, together with automatic sample changing apparatus, made it possible to use both isotopes, Fe^{55} and Fe^{59}, in the same experimental subjects. Thus, one isotope was used to measure the normal red-call volume of a subject, and the other isotope was employed to measure the degree of survival of transfused red cells in the same individual. Thus, each individual acted as his own biological control. Both forms of radioactive iron, Fe^{55} and Fe^{59}, produced by the M.I.T. cyclotron, were purified radiochemically and synthesized into ferric ammonium citrate.

When radioactive ferric ammonium citrate is injected intravenously into animals or humans it is rapidly removed from the blood stream. A large portion of the iron is retained in the body tissues concerned with iron storage. Hahn *et al*[7] gave ferric ammonium citrate to dogs, and assayed liver and spleen for both ferritin and radioactive iron, and found a relatively high level of radioactivity in the ferritin iron. It therefore seems highly probable that the radio-iron becomes intimately mixed with all of the body iron stores which are present at the time of the isotope injection, and hence is made available for hematopoietic needs.

It is generally believed that hemoglobin is "laid down" inside the developing erythrocyte. If some of the iron atoms involved in this synthesis are radioactive, a proportionate number of them will become an integral part of the new hemoglobin molecule within the newly developed cell. When the cell is released into the circulation, its presence in the blood stream can be detected as long as it remains morphologically intact. When the tagged red cell is destroyed, its hemoglobin derived iron is very rapidly removed from the plasma, to be re-used, to some extent at least, in the synthesis of new hemoglobin.

In general, each red cell contains approximately 0.1 per cent iron, or about a thousand million atoms of iron. In the radioactive donors, between one and ten of these iron atoms contains a radioactive nucleus, although the vast majority of the iron atoms in each red cell are ordinary stable iron atoms.

It has been demonstrated experimentally that there is no exchange of the radioactive iron in the red cells, either with plasma *in vitro* or *in vivo*, or with saline *in vitro*. Thus the method differs in important respects from the labeling of red blood cells by absorbed carbon monoxide or by adsorbed radioactive phosphorus. It furnishes a specific method of detecting the advent of new red cells, and to a certain extent, of following their fate in the circulation, and the disposition made of their contained iron.

The normal human erythrocyte is thought to have a life expectancy of about 100 days. Within this period it is possible to estimate the age of the oldest tagged cell in the circulation of a subject who has been given radio-iron. When these cells are removed from circulation some part of their contained radio-iron will eventually re-enter the circulation in the hemoglobin of new cells. If this "turnover" be allowed to continue for a sufficient period of time, the tagged cells will be of all ages from birth to death, or representative of a "mixed age population" of cells. The administration of the alternate radioactive isotope of iron at such a time will result in the production of new cells, the presence of which can be differentiated from the presence of "mixed age cells." Thus the behavior of young and old cells may be studied in the same subject.

[7] Hahn, P. F., Granick, S., Bale, W. F., and Michaelis, L. "Ferritin: VI. Conversion of Inorganic and Hemoglobin Iron into Ferritin Iron in the Animal Body. Storage Function of Ferritin Iron as Shown by Radioactive and Magnetic Measurements," *Journal of Biological Chemistry*, 150:407 (1943).

Average blood consumption is about one pint per casualty. At Okinawa, for example, 42,000 pints of blood were used for 42,500 casualties. In individual cases, however, the amount of blood transfused may greatly exceed the average. The record appears to be held by one man who was given 30 pints of blood in 48 hours; a second man received 12 pints in 12 hours, and a third, 41 pints in 38 days.

The use of radioactive iron in the blood stream was given long and careful consideration. Radioactive iron (Fe^{55}) administered to the donors was prepared as ferric ammonium citrate. Since the radio-iron was of very high specific activity, it was possible to obtain very high radioactivity levels in the donor's red cells by the administration of extremely small quantities of iron (as little as one milligram) and it required only from 10 days to two weeks to activate a donor. Using sterile precautions the donor was then bled into the preservative solution under investigation. This blood was then stored under varying conditions of temperature, and for varying lengths of time, before being transfused. Just prior to the administration of these stored bloods, the recipient's circulating red-cell volume was determined by means of a small infusion of red cells tagged with Fe^{59}. The preserved cells were then administered, and samples were withdrawn for radioactivity analysis. Since the recipient's pre-transfusion circulating red-cell volume had been measured, and since the quantity of transfused stored red cells tagged with Fe^{55}, as well as the activity of these cells, also was measured, the percentage of post-transfusion survival could be simply calculated from the Fe^{55} radioactivity level of the recipient's blood. If the stored cells had been well preserved, the great majority of them remained in the recipient's circulation, as evidenced by the fact that the recipient's radioactivity level did not appreciably change during the course of observation, which in some instances was prolonged for as much as 21 days. If the stored cells were poorly preserved, the recipient's radioactivity red-cell level progressively fell, at varying rates, reaching a low point usually within the first 24 hours after the receipt of the transfusion. This low point was used in computing the maximum survival of the preserved cells. Thereafter the recipient's red-cell radioactivity almost invariably rose. Since the only source of radioactivity was the tagged blood which had been given, it was apparent that this rise represented a re-utilization of the hemoglobin iron released from the cells which had not survived. These observations had no direct bearing on survival, but were important in the final evaluation of blood transfusion as a therapeutic measure.

All recipients and donors were carefully blood grouped. The majority of the donors were Blood Group O, and the recipients were of all four blood groups. All donors and all recipients were Rh positive.* All bloods were carefully cultured prior to administration. A few reactions occurred, characterized by chills and fever, and it was thought that these were due to accidental contamination of the blood with pyrogens, since no bacterial contamination was demonstrated. There were mild reactions characteristic of massive destruction of blood cells in those experiments in which extremely old bloods had been administered. None of the donors, however, showed any results which could be attributed to the effects of radiation of the isotopes administered. In the course of this work, 60 donors were prepared and almost 200 recipients received transfusions of tagged cells. These subjects have been followed for a minimum of one year and as long as five years, and none of them has shown any effects which can in any way be attributed to radiation. Their blood picture has remained normal, and regeneration of blood withdrawn from the donors has occurred at normal rates.

This method offers a very accurate measure of the percentage of transfused stored cells which resume their full functional capacity and remain intact in the recipient's blood stream for the residue of their normal life expectancy of about 100 days. The accuracy of the method is dependent in a large measure on the use of two isotopes of iron, the first, Fe^{59}, for the measurement of the recipient's red-cell volume, and the second, Fe^{55}, for tracing the actual fate of stored human erythrocytes after transfusion.

Survival of Blood Cells

In addition to studying the fate of red cells stored and administered as whole blood, experiments were conducted to determine the post-transfusion survival of red cells from which the plasma had been removed by centrifugation. In the early experiments various diluents were added to these packed cells immediately after centrifuging, in the hope that a suitable solution for the preservation of red cells only could be found. This was very desirable, since at the time the American Red Cross blood program was in operation in many large cities in the country. This blood, it should be recalled, was taken primarily for plasma, or for fractionation of plasma, and at no time during the war was any considerable use made of the residual red cells.

A large number and variety of preservative solutions both for whole blood and resuspended cells were studied by the techniques described above. These may be classified as follows for whole blood: (1) Simple solutions of sodium citrate. (2) Sodium citrate solutions to which dextrose had been added. These solutions remain alkaline. (3) Sodium citrate solutions to which dextrose and phosphate buffer solutions had been added. These solutions also are alkaline. (4) Sodium citrate solutions to which dextrose and citric acid had been added, the latter in amounts to lower the pH to 6.8 and 5.0. The ratio of diluent to whole blood taken varied considerably in the alkaline sodium-citrate-dextrose solutions but was much lower in the acidified citrate solutions. The solutions for resuspension of red cells were as follows: (1) Normal sodium chloride. (2) Citrate-sodium-chloride solutions buffered with phosphates and hydrochloric acids of pH's ranging from 6.8 to 3.8. (3) Sodium-citrate, sodium-chloride dextrose solutions to which a human globulin, Fraction IV-3, 4, had been added. (4) 10 per cent corn syrup. (5) Solutions, consisting of various concentrations of sodium chloride and dextrose, which were added just prior to the transfusion of the red cells after they had been stored in the refrigerator as packed cells.

In the whole blood experiments it was found that simple sodium citrate did not permit preservation of red cells for a period beyond five days. Two (*Continued on page 124*)

* A popular explanation of this term has been given in the article, "Rh Factor" *Life* magazine, June 10, 1946, pp. 139–145.

Rockets in Battle

By Willy Ley

Acme Photo

Modern version of rockets in battle is this photograph illustrating British antiaircraft rocket projectors used in 1944 to keep German bombers from completing assigned missions over England.

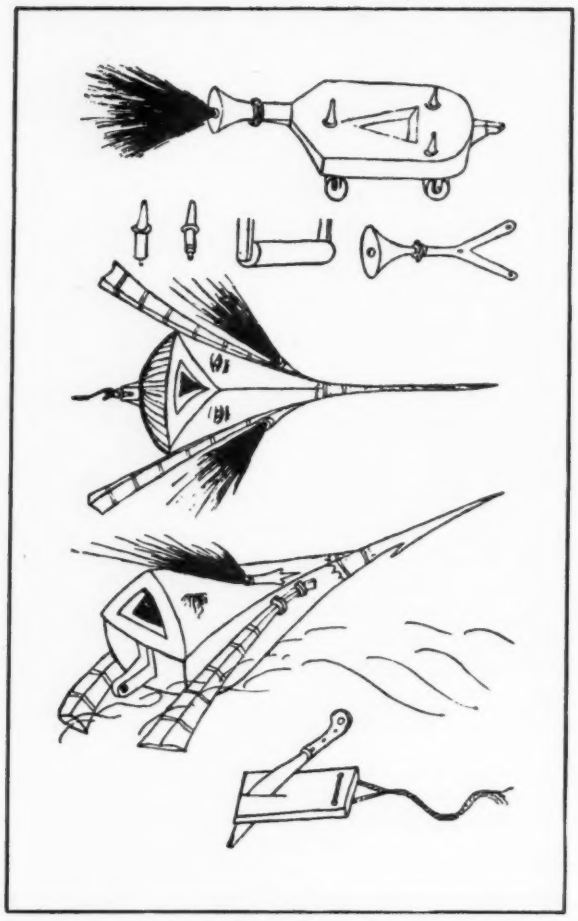
After centuries of painstaking development, restricted for long periods by the technological limitations of the times, progress in rockets took a big step forward during World War II. Although military necessity was the incentive for this progress, the knowledge gained is, of course, equally applicable to the furtherance of man's civilian objectives if he but chooses to direct his efforts into such channels. Certainly it is to be anticipated that the progress in the efficiency of propellants, in aerodynamical stability, in increased range and precision of flight which has recently been attained, will further man's peaceful, rather than military, affairs. Since the past proclaims the future, the most effective way of assuring the furtherance of such objectives begins with a review of previous development and applications, for warfare as well as for amusement, through which reaction-propelled missiles have already passed.

Memorialized in our national anthem, "the rockets' red glare" is not merely a figure of speech, despite the limited use of rockets during the past century. The reason why World War II brought about a new realization of the importance of these airborne devices is merely that it gave the first example in more than a century in which rocket projectiles played an important role. The Russians used several types of bombardment rockets, at least one of them manufactured in Tennessee; the British had their Z-guns throwing rockets against German bomber formations; in addition to the long-range rocket A-4 (V-2), the Germans had several types of *Nebelwerfer* and *Wurfgerät* and dozens of experimental types. In addition to the well-known bazooka, our own fighting forces had a total array of 24 types of rockets, the biggest weighing some 1,200 pounds. Their characteristics are summarized at the end of this article.

The use of rockets as weapons of war represents a revival of earlier military techniques. Even that term is somewhat too weak in one respect: Revival somehow implies a second time; actually, World War II was the cause for the third wave of war rockets in military history. The first wave followed soon after the invention of the rocket, about 1200, and lasted, with sporadic applications, for about two centuries. During the second wave, which began at the end of the Eighteenth Century and lasted for about two decades, the well-known lines in our national anthem were written. The third wave comprises World War II. Between 1813 and 1940 there had been no major use of war rockets. A few occasional applications did take place during this interval, but these were more of a curiosity than an indication of a trend. In fact, what use was made of rockets in the century of this country's greatest development seemed to indicate that the trend ran the other way. The Nineteenth Century war rocket appeared to be the last survival of the second wave of development, a last hissing flickering of a past glory. It was as anachronistic in the art of war of 1866 or of 1915 and 1916 as the mammal platypus and the fish Latimeria are to the zoology of 1946.

Rocket Origins

There is no need to devote much time or space to the first wave of war rockets. Historical research has shown that the rocket was invented in China around the year 1200. Indications are that the first rocket was developed gradually from the fire arrows by substituting gunpowderlike mixtures for other kinds of incendiaries formerly attached to fire arrows. This, at least, is how the French Sinologist, St. Julien, read the Chinese chronicle in question. According to his translation three "secret weapons"



Drawings from the sketchbook of the Italian "war engineer" Joanes de Fontana, about 1420. The top diagram illustrates a rocket-propelled car with detail sketches indicating that three rockets are to be used. A rocket-propelled naval torpedo, painted as the head of a sea monster, "to deceive the enemy" is shown in the center. The bottom sketch shows a piece of board forming the stabilizing tail of the torpedo in the manner of a kite tail. Presumably the dagger forced through the board is to indicate that it is made of wood.

made their appearance simultaneously during that famous siege. One of them was a bomb, a powder-filled, metal container which was lowered by means of chains from the walls of the city. The second was a spear with a crude Roman candle tied to its tip and appropriately named "the lance of the storming fire." The third secret weapon was the "arrow of flying fire" which was stated to "suddenly fly away in a straight line." The third weapon obviously was a weapon similar to a fire arrow and rocket, but more nearly resembling the latter.

Some 20 years later, war rockets were known to the Arabs and, almost simultaneously, to the Europeans. The chronicle of the city of Cologne (for the year 1258) mentions them, and several writers of that time, including such famous clerics as Roger Bacon and Albertus Magnus, made reference to rockets in their works. Regarding what we now call tactical employment, the descendant continued the work of its ancestor; rockets were used in the same manner as the older fire arrows; in fact, they were often used in conjunction with fire arrows.

By 1550 rockets had lost much of their military value and were used primarily as fireworks for amusement only. As a weapon they survived only at sea, where the tarred rigging of the sailing vessel offered a rather large and easily inflammable target. War rockets might still be a neglected possibility had it not been for the princes of Mysore in India who, almost two centuries ago, ordered their artisans to increase the size of fireworks rockets and then set about to train special units of their extensive bodyguards in the use of such rockets. When the British attacked the Indian city of Seringapatam just before the dawn of the Nineteenth Century, the war rockets of the princes of Mysore dealt them a crushing reverse. The British, it seems, had learned that the thundering sweep of a massed cavalry attack was the simplest means of crushing native resistance. But horses were vulnerable to the flashing streaks of oncoming rockets, and they shied from the violent roar which often resembled the groans of a gigantic animal.

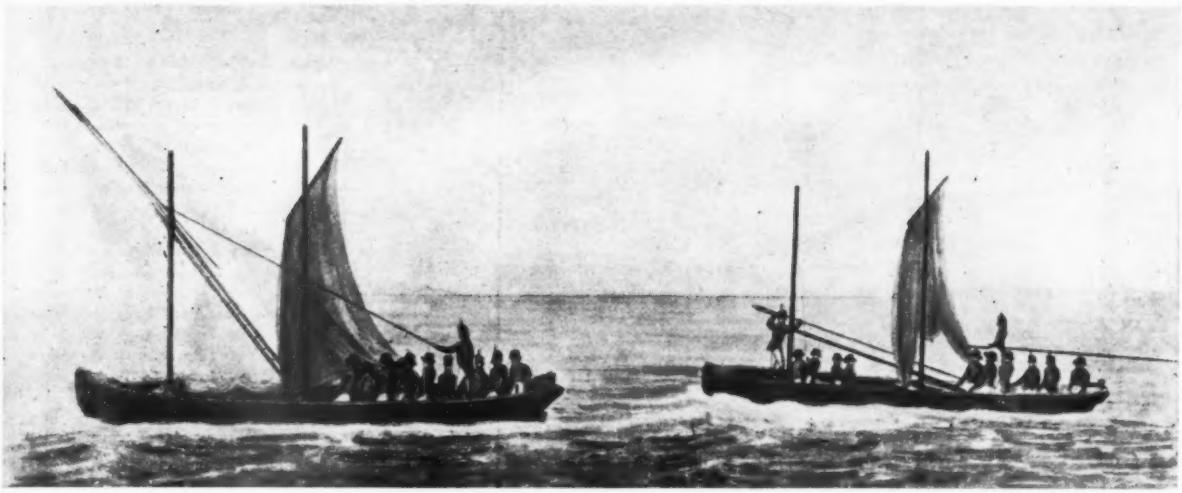
Breakdown of Trade Secrets

When the news of the Indian war rockets reached England, William Congreve, a young artillery officer, made the rounds of London shops, trying to purchase rockets. He found some, made presumably for signaling purposes, examined them carefully, and then fired them in order to establish their performance. The range of the English rockets was between 500 and 600 yards, less than half that of the Indian war rockets, but the examination had shown that improvements were possible. After some work, in the course of which Congreve discovered and partly discarded most of the trade secrets which the fireworks makers had guarded so jealously, he produced rockets with a range of about 2,000 yards, more than enough to compete with most of the artillery of that day.

In 1805 the improved rockets were demonstrated for the first time, but they were not successful in actual use later in the same year. The initial failure seems to have been merely the result of poor employment and small expenditure, for only one year later Congreve's war rockets, equipped with incendiary warheads, set afire a large section of Boulogne. Another year later, in 1807, a mass use of 25,000 rockets caused Copenhagen to burn to the ground.

Danzig was forced to surrender in 1813 because Congreve rockets set the food stores afire, and the big battle of Leipzig, which sealed Napoleon's fate, also saw British war rockets in effective action during the preliminary maneuvering.

Congreve himself was elated. He called his rockets "the soul of artillery without the body" and wrote several treatises extolling their virtues. These treatises now read very much like the more recent explanations on the advantages and disadvantages of rocket fire which were written for civilians during World War II. Round for round, rockets were noticeably heavier than other ammunition, but they did not need heavy artillery pieces for their firing. They could be launched from light metal tubes, even from wooden launching racks if necessary, and, if everything else failed, temporary makeshifts, assembled on the battlefield, could be used. Furthermore, a much higher density of fire could be achieved for short intervals of time than with guns of any type. The complete absence of recoil is another valuable characteristic of rockets which Congreve used to advantage, firing rockets



British rocket boats, 1816

from special, and rather small, rocket boats which could not have carried guns.[1]

The advantages of war rockets could not be realized as fully in Congreve's time as they could be realized a century later. Even in the early Nineteenth Century, however, a variety of uses were apparent, as can be seen from the tabulation of rockets manufactured in the British arsenals.

The tactical use of rocket weapons was in the hands of the Rocket Corps, an independent branch of the British services. Austria, Greece, and Russia followed suit by creating similar independent rocket corps. Denmark, Egypt, France, Italy, the Netherlands, Poland, Prussia, Sardinia, Spain, and Sweden created rocket batteries which were part of their artillery. The Swiss Rocket Corps was intended to be independent and was nicely organized down to the smallest detail, but only on paper. The United States Army had rocket batteries, too; military historians in Washington are still hunting through archives in an attempt to find out whether they were independent or classified as artillery batteries.

[1] In World War II, the absence of rocket recoil was utilized to build airplanes with firing power considerably greater than that obtainable from the more usual ordnance.

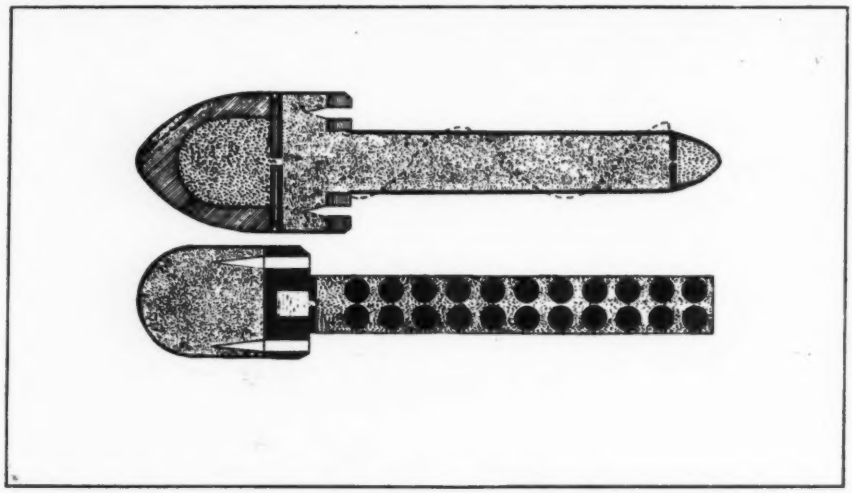
The Decline of Rockets

The organization of rocket corps in the countries enumerated above took time. It took even more time to manufacture rockets (although many countries bought them from Great Britain) and to get down to tests and to target practice. When things had progressed to this point, it dawned on those in charge that the artillery had made such mighty strides in the meantime as to make rockets superfluous. The new guns outranged the

Early Nineteenth-Century Rockets Manufactured by British Arsenals

Weight and Designation	Type of Projectile Carried	Extreme Range (Yards)	Elevation for Extreme Range (Degrees)
42-pound Carcass Rocket*	Large: 18-pound carcass Small: 12-pound carcass	3,000	60
42-pound Shell Rocket	Large: 12-pound spherical bomb Small: 5½-pound spherical bomb		
32-pound Carcass Rocket	Large: 18-pound carcass	2,000	60
	Medium: 12-pound carcass	2,500	55–60
	Small: 8-pound carcass	3,000	55
32-pound Shell Rocket	9-pound spherical bomb	3,000	50
32-pound Case Shot Rocket	Large: 200 carbine balls	2,500	55
	Small: 100 carbine balls	3,000	50
32-pound Explosive Rocket	5–12 pounds of gunpowder	2,500–3,000	55
12-pound Case Shot Rocket	Large: 72 carbine balls	2,000	45
	Small: 48 carbine balls	2,500	45
Flare Rockets	With parachute		90

** The now fairly obsolete term "carcass" refers to a thin-walled metal container filled with incendiary substances. In the case of the Congreve rockets, the incendiary material produced a biting and choking smoke prohibiting the approach by would-be fire fighters.*



Improved war rockets as proposed by Montgéry in his book Traité des fusées de Guerre *(1825). The upper diagram shows a rocket with an explosive charge in a fairly heavy metal casing with driving charge contained in the tube serving as a guiding stick. A ridge running around this tube was supposed to impart rotation about the longitudinal axis. The lower diagram shows a war rocket in which the guiding stick is also tubular and contains a charge of powder and lead balls. It seems unlikely that such rockets were actually tried.*

rockets considerably, and they offered the additional advantage of being much more accurate. In all the enthusiasm about Sir William Congreve's new weapon (the "Sir," like the "General," was a late addition to his name), the inherent drawbacks of rockets had been overlooked.

Rockets were not quite as safe to handle as guns, they deteriorated much more rapidly in storage than artillery ammunition, and they were not accurate. At first, both guns and rockets had been equally inaccurate. Now guns were less inaccurate than before, and at that time everybody wanted accurate fire against single enemy units. The concept of area beating was the last tactical thought that would occur to any officer. It was probably not even gentlemanly to think of such a method.

The many rocket corps were quietly disbanded. The Austrian Corps had the longest life but followed the way of all the others after it had produced a rather miserable performance against the Prussians in 1866. Some two dozen formerly secret treatises were quietly declassified and began to appear on the general library shelves under "military." The Civil War was fought without rockets.

The British kept war rockets with solid steel heads on the list of issue weapons. They were issued only to the Colonial Services who did not know what to do with them. It seemed that war rockets might be good for incendiary purposes, but there are in print reports of colonial officers relating that such rockets, fired at native grass huts, penetrated without igniting them. Once again the value of rockets was reduced to the level of fireworks.

During World War I only one serious military application of rockets was made. French pilots used large, naval, signal rockets to set afire German captive balloons which served as artillery observers. That was all.

Fashion and Technology

There can be little doubt that to a certain extent the rather extreme fluctuations of rocket popularity were due to something which, for want of a better term, may be called fashion. Certainly there were instances in which the proper use of rockets might have shortened wars. During the Civil War, Atlanta would have been less of an obstacle to Sherman if some 20,000 Congreve rockets had been at his disposal. In the Franco-Prussian war of 1870–1871 several situations arose in which Congreve rockets could have played an important role. Certainly it would not have required much work during World War I to utilize an adaptation of the French signal rockets for ground strafing and possibly even for antisubmarine use.

The greater part of those curious fluctuations of the rocket's history can be traced to technological causes. Again, the smaller part of the technological causes has to be sought in the technology of the artillery weapons. Twice in the course of history firearms experienced a period of considerable improvement just at the time when war rockets were advocated and in use. Even World War II offers such an example: The war rocket was employed for uses in which the absence of recoil was the main consideration and the comparative lack of accuracy could be accepted because no more accurate recoilless weapon was available. It is not unreasonable to believe that the modern recoilless gun will replace rockets in such applications.

The main reason, however, for the periodic reappearance of the war rocket was the technological improvement of the rockets themselves. An examination of methods of manufacturing rockets will indicate why the Congreve rockets, highly useful for several years, lost their advantage when manufacturing limitations prevented further technological improvement.

We do not know how the rocket makers of the period between 1250 and 1350 made their rockets. We can only surmise that they made the best gunpowder they knew how and stuffed it into their casings as tightly as they could. The Chinese, we know, used bamboo for those casings; a German manuscript dated 1405 stated that the casing was a tube of stiff leather.

Rocket Manufacture

By about the year 1500 rocket manufacture had settled down to a routine. The propellant was a black-powder mixture of the following recipe: First, gunpowder was prepared by mixing six parts (by weight) of saltpeter with one part each of charcoal and of sulphur. The finished gunpowder was then carefully mixed with another two parts of charcoal to decrease its burning speed. The casing was made of many layers of thin paper pasted together in the form of a hollow cylinder. While still wet, the casing was choked by means of a soaped string applied from the outside, to produce a constriction in the cardboard

tube so that it resembled an hour glass. Two wooden plugs with rounded ends prevented the pasteboard tube from collapsing beyond the choked portion. The restriction was placed one tube diameter from one end and the diameter of the aperture thus formed was two-thirds of the inside diameter of the tube.

Then, each time the tube was filled by about one diameter, the powder mixture was first tamped down and then hammered in with "twenty-five strong blowes." A trade secret of the time called for the insertion of a conical iron spindle in the shorter section of the tube, from the end to the constriction so that the powder cylinder resulting from the hammering had a conical center hole. Only the top section, about two tube diameters in length, was solid. The purpose of the conical center hole was to increase the burning surface, since the normal cross section of the tube could not produce enough combustion gas to lift the rocket.

The rocket, completed according to the above directions, would have been unstable in flight. To overcome this defect, a long, thin guiding stick was provided which, although representing a great deal of dead weight, could not be dispensed with.

When Congreve examined rockets made in this manner (the intervening 300 years had not brought any changes) he reasoned that the most obvious improvement would be a higher condensation of the black-powder mixture. He knew that the specific gravity of the propellent in such handmade fireworks rockets, of the order of 1.25 to 1.30, could be increased by using smaller portions of black powder. But there was a safety limit. When the rocket was hammered too hard it would explode for the reason that the air trapped between the powder particles may be heated enough by compression to ignite the powder.

It was possible to avoid this danger by wetting the black-powder mixture with alcohol. The alcohol, which contained some 30 to 35 per cent water, not only replaced the air to a large extent but also absorbed a great deal of the heat of compression. Consequently, Congreve rockets were made by using this so-called "wet procedure." The higher compression naturally required stronger casings, and the pasteboard tube was replaced by an iron tube, something which the rocket makers of the princes of Mysore had done, too. The hand mallet was replaced by a drop weight, hoisted by muscle power after each blow. Congreve's competitors and imitators even went so far as to place the rocket casing to be loaded into a large tub containing water, so that the powder mixture was cooled through the walls of the metallic casing.

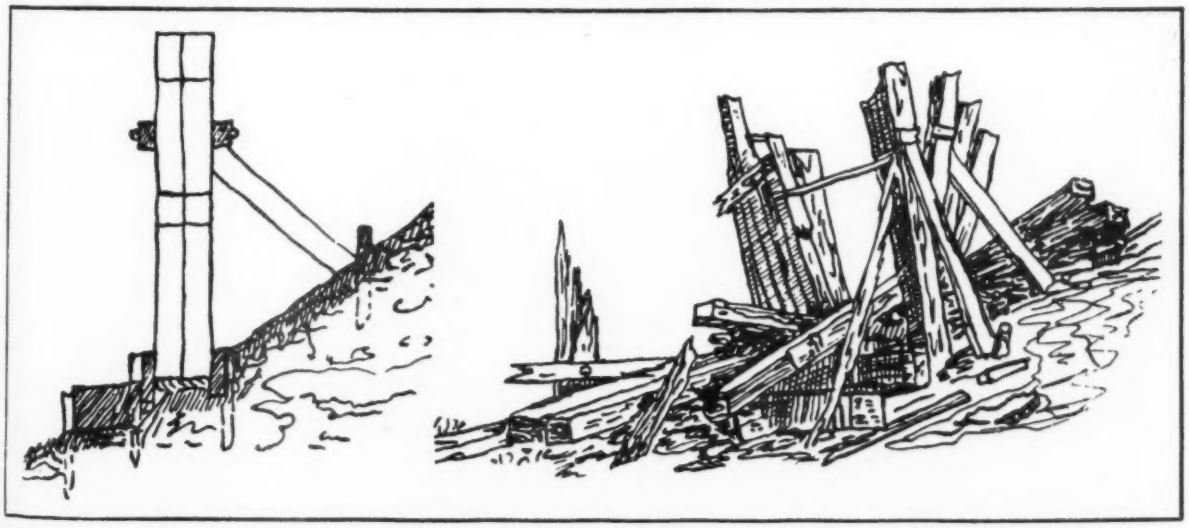
Another improvement upon handicraft was to load the rocket casings solidly and to produce the center hole by boring and reaming. With all these refinements it became possible to increase the density of the propellant to 1.5 and even 1.6 and to make larger rockets than ever before. But the possible limits were reached within less than a decade; no further improvement was possible.

Fragile! Handle with Care

After these rockets had been made they required a great deal of skilled care. In the first place, it was necessary to dry them carefully — a process requiring several weeks — and then they had to be handled and stored with utmost caution. A black-powder mixture compressed to a density of 1.5 or thereabouts is, unfortunately, very brittle, and even a minor concussion, or a sudden change in temperature, is apt to form fine cracks in the propellant. Even now it might still be exceedingly difficult to devise a method for detecting such cracks; it was a completely hopeless problem a century ago. It is these fine cracks which lead to explosions, for when the flame reaches such a crevice it works its way into the crack, causing a sudden increase in the amount of combustion gases generated.

The increase in the generation of gas is only one of the dangers to be expected from the fine cracks in the propellant. Usually a lump of propellant is worked loose by the flame entering a crack. If the lump is small enough to pass the exhaust nozzle, it may be discharged without further consequence, but if it is large enough to block the exhaust nozzle, even momentarily, a bursting of the casing is a certainty.

The fissure of the propellant was a difficulty which fireworks makers could not circumvent. Even as late as 1928 the most carefully made high-compression rockets were



Published originally in a French military manual, about 1825, this drawing illustrates the effect of a Congreve rocket with explosive charge upon striking a target wall erected of oak planks about six inches thick.

still subject to explosion because of such cracks. By then a highly developed technology, using hydraulic presses and ingenious methods of cooling while loading the rocket, had succeeded in compressing especially stable black-powder mixtures to densities of 1.80 and 1.85. The number of explosions on the proving ground was 10 to 15 per cent of those tested. In spite of all the precautions the manufacturer could think of, failures rose to about 40 per cent, in some cases to 80 per cent, when rockets were transported less than 200 miles.[2]

These are the reasons why the second wave of war-rocket development initiated by Congreve rather quickly exhausted the technological possibilities of the times and why the only rockets available between 1850 and 1920 did not exceed two inches in diameter. By keeping the rockets relatively small and the density of the propellant fairly low (about 1.35) the danger of cracks could be greatly reduced. Even so, failures of five per cent were expected every time a given batch of rockets was shipped, and, in addition, for every month of storage, failures rose another one per cent. The actual number of failures was not quite so bad.

Some Sidelines

Naturally such rockets could not be expected to do more than carry signal lights as a routine job, but occasionally they did perform other feats. Experiments, generally unsuccessful, were made with rocket harpoons, but the line-throwing rocket, a direct descendant of the Congreve war rocket, was standard equipment for rescue crews at the seashore. Used when a vessel had been stranded within a few hundred yards of the shore, it carried a line to the vessel, by means of which a heavier line was hauled across and finally a breeches buoy attached to the line. In Switzerland similar rockets were used to lay temporary telephone wires across the tree-tops of wooded mountain slopes.

But there were no war rockets left, except those British Colonial Service rockets with solid steel head. They were based on the invention of an American, William Hale, who in 1846 succeeded in eliminating the dead weight of the long guiding stick. Hale did this by placing three curved metal vanes in the exhaust nozzle. The exhaust blast, striking those vanes, imparted a spin to the rocket which stabilized it.

[2] These figures refer to the high-compression rockets used in 1928 in the widely publicized rocket automobiles of Fritz von Opel in Germany.

To sum up the *status quo* of the years following World War I: The solid propellant rocket was handicapped by a practical maximum size beyond which rockets became too dangerous, both in manufacture and in use. This maximum size was too small to be of military use, however, and hence there were no war rockets.

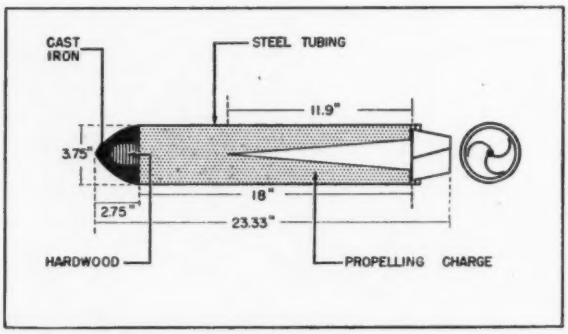
To anybody who clearly realized these things, a possible solution became apparent very quickly. It was "only" necessary to find a solid propellant which, while at least as powerful as black powder compressed to a density of 1.8 or higher, would not be brittle and hence not crack. The smokeless powders, some of which are actually flexible, suggested themselves.

Improved Propellants

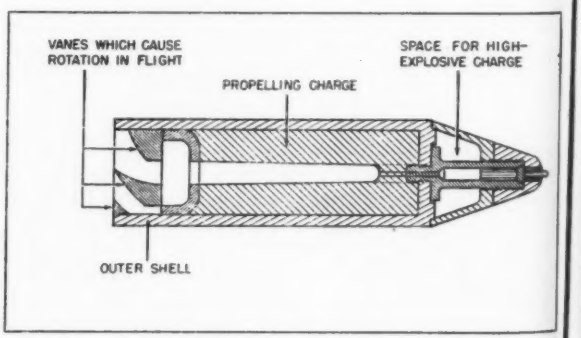
But there was a long, difficult road between the conception of this idea and its practical realization. It was necessary to form smokeless powder into rods large enough to burn for as long as two seconds and shaped in such a way that the rate of burning would be more or less uniform. There were two basic methods. The American method involved the use of a solvent. The smokeless powder, derived from guncotton and nitroglycerin with other chemicals added, was made into a thick black paste from which the powder rods were then extruded. The extrusion process worked well and involved little danger, but because of the need for drying the solvent out of the "grains," no great thickness of material was possible.

The British had developed a dry extrusion process for their rockets in which dry cordite was rolled into sheets, which were then wound into tight rolls and extruded through dies. At first, dry extrusion was considered rather dangerous in this country, and not without justification. Ultimately, it was adopted, however, and finally most American war rockets were propelled by fuels made by dry extrusion. In this method, grains were formed, some of which were as much as five feet long and four inches thick with a maximum weight of more than 40 pounds apiece.

Three types of grains were in use. One was simply tubular, like thick-walled tubing. Each rocket propelled by such grains received a fair number of them. Another type was a thick-walled tube with three external ridges, but the type most frequently used was a long, straight grain, the cross section of which looked like a thick-armed cross. In order to prevent burning from the ends, cruciform plastic inhibitors were placed over the ends. Except for the largest (*Continued on page 116*)



A 24-pound British war rocket, one of the many forerunners of the Bazooka. The diagram appeared in the official British Treatise on Ammunition *of 1905.*



Aerial torpedo of 1906 invented by the Swedish Lieutenant Colonel Baron von Unge and bought from him by Friedrich Krupp in Essen. Experimental models weighed as much as 110 pounds.

Preface to

By Paul Meadows

Post-Industrialism

The Ebb and Flow of Human Affairs Now Work Against Centralized Bigness

As a way of life industrialism can hardly be expected to remain unchanged for in our machine technology we have inherently a science of change. Machine technology is a unique system of mankind for no other system has ever made change the mechanism of survival.

It is a paradox that in industrial societies, little attention is paid to the question of how long or how much an entity can change and still retain its identity. That industrialism should undergo far-reaching, continuous modification without sustaining a basic transformation is a logical contradiction. Yet, the prospect that modern industrial people might live in a post-industrial society is likely to appear to them as fantastic. Every age has its utopia, and the machine civilization we know so well is ours. Our entire outlook on life and our philosophy of history and the future are identified with machine technology as we have known it.

If we pause to reflect, however, we can remember easily enough that there have been many pre-industrial civilizations and that industrialism itself is a product of a long, ceaseless, cultural evolution. Logically, therefore, we might expect a post-industrial civilization.

Unfortunately, the concept of post-industrialism is likely to frighten industrial people. It is a term freighted with emotional protests and suggests a counter-revolution against the machine. For example, out of a revulsion from Nineteenth-Century English industrialism the arts and crafts movement in Victorian England sought to achieve a revival of the handicraft arts in the name of certain aesthetic standards of craftsmanship. Because of the abuses of "the system" industrialism has revolted its share of prophets and poets.

Yet post-industrialism is really a much calmer word than the example above seems to indicate. It suggests a new system of industrial technics, evolved out of the old, and already present in many forms; it refers to reaction tendencies generated by industrialism itself. The literature rejecting Nineteenth- and early Twentieth-Century industrialism reveals the focus of this new industrial culture.

The Language of Industrial Protest

In a negative sense, post-industrialism represents a protest against the trends in concentration and enlarge-

Photo by H. Armstrong Roberts

The centralization of electrical power generation has made dispersion of industry, people, and institutions both necessary and possible.

The technological mastery of electrical power — hardly more than a half century in service — represents a new industrial revolution in which decentralization is likely.

ment of industrialism. It expresses a dissatisfaction with the forms of industrial life as we have known them; it is tired of big business, big industry, big cities, big labor, and big government. Lewis Mumford has called the current but disappearing phase of industrialism the paleotechnic stage. It is an epoch of industrial development the central feature of which has been shapeless, sprawling giantism. The "sensate industrial town," as Mumford terms it,[1] is the epitome of massed and massive mechanization. The tentacular metropolis is the temple of a paleotechnic (industrial) civilization, and the center of its adoration of sheer size.

Even before the advent of the nucleonic age and atomic warfare, it was clear to many discerning minds that bigness is a transitory phenomenon. Following Malthus' famous concept, it was possible to perceive that a number of negative checks were already operating to inhibit further increase in size.

The modern "megalopolis" is a paradox. Mumford calls it "an outstanding example of a peculiar cultural lag within the realm of technics itself; namely, the continuation by advanced neotechnic means of the forms and ends of paleotechnic civilization."[2] The giant industrial community suffers from congestion, and sheer size has imposed severe limitations upon it. There are the physical limits of water supply, sewage disposal, traffic control, physical distance. There are the economic limits of increasing costs, frozen price pyramids of land rents and mortgages, civic depletion, urban blight. There are the social limits of population density, complexity of organization, loss of social control, institutional impoverishment, and loss of vitality. In a word, the industrial city has had to come to terms with the familiar principle of diminishing returns.

"At any given time and in any given condition of industrial technique," said Alfred Marshall, "there is likely to be a point, beyond which further increase in size gives little further increase in economy and efficiency."[3] Both in business and industry, as well as in social life, size becomes self-penalizing. Thus, the larger the plant, the more fixed the capital and the more restricted the adaptability. Bigness maximizes the problems of administration, and, as a corollary, of bureaucracy also. It breeds bigness, for the greater the fixed costs, the greater the drive toward expansion in order to cover costs. Indeed, bigness has become a kind of social insurance institution for enterprisers and managers who, unfortunately, have their premiums paid by the consuming public. The rule of massed mechanization, which has been the passion of industrial people, has run counter to the law of diminishing returns. Herein lies the hope of post-industrialism.

Positively, post-industrialism is a culture pattern focused on the tendency of decentralization which has already been set in motion by the forces of industrial society. The utopia of the post-industrial age still depends greatly upon the machine but differs from our present era in that the post-industrial machine operates in a decentralized setting. Post-industrialism is a decentralized way of life; its key word is decentralization.

Writers on decentralized technics are not in agreement on what is being, or should be, decentralized.

A topographic school of decentralists talks about the dispersion and expansion of business enterprises, the movement of business units to the urban fringe, branch plants, suburbanism, and rural industries. A structural school of decentralists refers to the development of small-scale industries, the abandonment of large-scale operations, regional industries for regional markets, and small community enterprises. An organic school of decentralists speaks glowingly of a flight from the city, back to nature; it concerns itself with homestead projects, cooperative and self-sufficient communities, the rejection of urbanism, or the dispersion of population. Each group of writers makes out a different case for decentralism: the first, a statistical case; the second, an economic one; the third, sociological. The first group feels that the word decentralism is perhaps too strong to describe the trends it sees in process. The other two groups argue that their types of decentralism represent the fruition of real liberalism, the realization of genuine human values. But all groups agree on the fact that a reversal of Nineteenth-Century industrialism is on the way; a movement toward smaller, dispersed, more manipulatable technical and social forms is on foot.

Post-Industrialism: The Inner and Outer Structures

It is imperative that the possibility of a post-industrial culture should not be made to rest upon the wish-fulfillments of industrial protestants. Post-industrialism is not an imaginary construct; quite the contrary.

A post-industrial culture is coming into being by the same process that produced industrialism, i.e., via machine technology. Elsewhere it has been pointed out that industrial civilization is based on the principles of science

[1] *The Culture of Cities* by Lewis Mumford. (New York City: Harcourt Brace, 1938, page 145.)

[2] Op. cit. page 235.

[3] *Industry and Trade* by Alfred Marshall (London: Macmillan, 1927, page 249.)

and that it centers around the machine as a system of controlled efficiency. Indeed, our shorthand expression for the industrial economy is "the machine," by which we connote not only the use of science for the elaboration of a machine technology but also the concept of automaticity through disciplined power. The impetus toward post-industrialism originates at this point — the point of power. For post-industrialism, unmistakably a power age, is based on a historically novel source of power — electricity.

Electricity has given industrial people a new technical base, one which is exemplified in such forms as the dynamo, the motor, and the power transmission line. Through radio and wire methods of communication, electricity has made possible the seclusion of human beings without their isolation. Indeed the technological mastery of this source of power — hardly more than half a century in service — represents a new industrial revolution. The power sources and machines of the older industrialism required concentration of machines, materials, man power, and markets. Such is distinctly not the case with the new industrialism.

Paradoxically, centralization of electrical power generation has made dispersion of industry, people, and institutions both necessary and possible. Electric power is a concentrated form of energy which requires no concentration of population or industry. From its widespread availability flow a number of technical and social sequences. Smaller and more flexible factories are made possible, production revolves around more flexible machine arrangements, and remote control of industrial operations becomes possible and necessary. Automatic manufacturing becomes of increasing importance and a new type of industrial worker emerges — the inspector, switch-thrower, or dial-watcher. Many, if not most, of the remaining industrial operations may be further mechanized. Ultimately a new kind of technological unemployment arises: the disemployment of the machine itself. Mobility and reduction in prime costs and size of operations replace the older drive toward massed machine technics and personnel. The new system of industrial production promises to be as revolutionary as the one which we identify with the Nineteenth Century.

The productive system of the older industrial economy has evolved an outer structure of relations which is usually described in some such terms as the factory, the firm, the city. It should be expected that the productive system of the new industrial technology will inevitably introduce changes in this outer structure.

Enough statistical evidence is at hand to show that the factory system is already undergoing a significant series of changes. One of them, for example, is the diffusion of factory units; a diffusion which is paralleled by a similar translocation of business units. The study of population redistribution noted during the 'Thirties marked intra-regional movements. Sizable industrial and business relocation from large, congested nuclear cities to smaller communities in the peripheries was much in evidence.[4] The war has undeniably hastened this process. Part of the sequence is simply an addition of new locations to old ones in a general spreading-out of operations. Part of it is the development of new regional industries and markets. Part of it is a governmentally supported search for industries and businesses which are peculiarly rural, or rural-urban industries.

[4] *Is Industry Decentralizing?* by Daniel B. Creamer. (Philadelphia: University of Pennsylvania Press, 1935.)

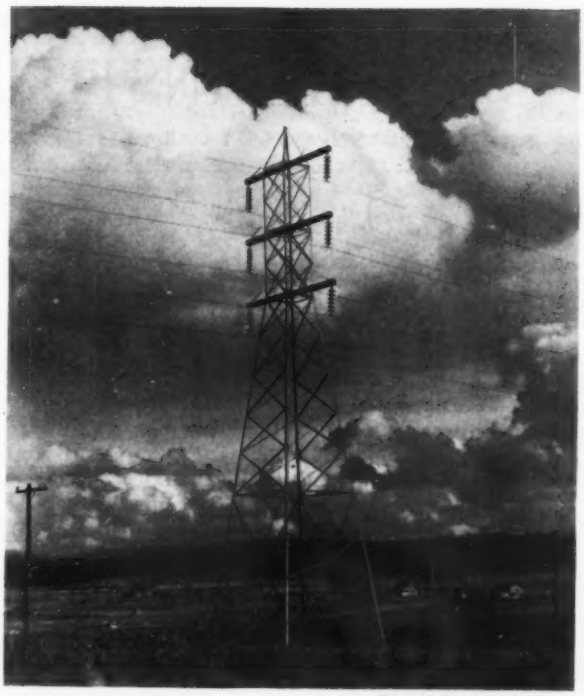


Photo by H. Armstrong Roberts

Electricity has given industrial people a new technical base; one which is exemplified in such forms as the dynamo, the motor, and the power transmission line.

Another modification in the outer structure of industrialism, also already in evidence, is the transformation of the pattern of community living. Study after study has shown that, in recent years, the giant central cities of industrialism are not growing at the rate which characterizes the growth of the metropolitan fringe communities. The suburb, a specialized segment of the industrial city, is a symptom of this community change. The main goals of movement are non-metropolitan.

Indeed, what is happening is the appearance of a new social pattern, in which the industrial city surrenders its dominance over the hinterland. Financial economy and technical mobility have diminished the need for close settlement at the same time that they have increased the possibility of physical movement. The centripetal city, as architect Frank Lloyd Wright calls it, is giving way to the centrifugal city, and a new bio-technical regionalism which seeks a life-conditioned (rather than a machine-dominated) environment for industrial people is coming into being.

The Human Appraisal of Post-Industrialism

There have been sketched here only a few of the many aspects of the new industrialism. One of the most important aspects of all is the shift in human values which post-industrialism promises to make possible.

The massed mechanization of the older industrialism has tended to create more problems than it can solve. In *The Culture of Cities* Lewis Mumford commented on the paradox of modern metropolitan civilization. Large cities represent "the existence of a rational collective organization of the physical means of life (*Continued on page 120*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Of Things to Come

HERALDING important changes in the executive management of the Alumni Association of M.I.T. and in the administration of the office of the Dean of Students, President Karl T. Compton and Harold Bugbee, '20, President of the Alumni Association, have announced the appointment of Dean H. E. Lobdell, '17, to the newly created position of Executive Vice-president of the Alumni Association of M.I.T. The Reverend Everett Moore Baker, D.D., minister of the First Unitarian Church of Cleveland and former Vice-president of the American Unitarian Association, will succeed Dean Lobdell as Dean of Students, and the Associate Dean of Students, Thomas P. Pitré, has been advanced to the new post of Dean of Freshmen.

In his new post, which he will assume January 1, Mr. Lobdell will have direct responsibility for administering the affairs of the Alumni Association and for serving as director of alumni relations for the Institute.

Professor Charles E Locke, '96, will continue as secretary of the Alumni Association, which office he has graced for 16 years. Ralph T. Jope, '28, also will continue as treasurer of the Association and business manager of The Review, Henry B. Kane, '24, as director of the Alumni Fund, and Beverly Dudley, '35, as editor of The Review.

Emphasizing the import of the new executive vice-presidency in a joint statement with Mr. Bugbee, President Compton said: "The activities of the Alumni Association, which represents an influential group of nearly 37,000 former students, are constantly increasing and now require the full-time, active direction of an outstanding administrative officer. In appointing Mr. Lobdell as its first executive vice-president, the Alumni Association has taken a step which we are confident will be of great importance to the future development of the Institute and of equal value to our Alumni. As dean of students for many years and as publisher of The Technology Review, Mr. Lobdell has established extraordinarily wide contacts with M.I.T. Alumni and is ideally qualified by executive experience and knowledge of the Institute for a post of leadership in carrying out the plans of an expanding program of alumni activity.

"In addition to his responsibilities as executive officer of the Alumni Association, Mr. Lobdell will serve as adviser to the President of the Institute on all matters of alumni relationships."

The nomination of Dean Lobdell, which was unanimously adopted by the Executive Committee, was made by the Special Committee on Improving the Organization and Operation of the Alumni Association, of which committee Marshall B. Dalton, '15, was chairman. In their report, Mr. Dalton's committee said in part:

"Your committee has delayed its final selection because it was more interested in securing what it unanimously felt was the right man for the position than in the precise time for his appointment. In the original report, dated April 24, 1944, your committee stated the following qualifications for the individual to be selected if such a person could be found:

"He should be an alumnus of Technology.

"He should be of sufficient maturity and accomplishment to command the respect of all age groups who should be interested in the future of the Institute, including potential students of Technology, undergraduates, graduate students, alumnae and alumni, and leaders of industry.

"He should be acceptable to the Institute Administration and capable of rendering them service.

"If possible he should have an intimate association with the Institute Administration and its staff, so that he thoroughly understands the organization, the operation, the aims, history and traditions of Technology.

"Your committee believes that Mr. Lobdell qualifies to an extraordinary degree on all of the above counts, and that the usefulness of the Alumni Association to its members and to Technology will be greatly increased by this appointment."

Member of the Institute's Class of 1917, Mr. Lobdell enlisted in the United States Army when this country entered World War I, and served as an infantry officer until the autumn of 1919 when he joined the Institute's staff and was appointed assistant to the director of the Division of Industrial Co-operation and Research, holding that office until he became assistant dean in 1921. He was editor of The Technology Review from 1922 to 1930 and since 1930 has been The Review's publisher.

Thus, for the past 25 years, Mr. Lobdell has been associated with the Dean's Office, the chief responsibility having been his since the death of Dean Henry P. Talbot, '85, in 1927. Since its establishment in 1930, he has been chairman of the Technology Loan Fund Board which has already administered loans of $1,900,000 to some 2,600 Technology students. He remains head of the board of this important student aid fund.

In 1933–1934 Dean Lobdell was president of the National Association of Deans, and since 1933 has been national vice-president of Phi Kappa Sigma fraternity. His clubs are the St. Botolph and Engineers clubs of Boston, the Century, Collectors, University, and Technology clubs of New York, and the Army and Navy Club of Washington.

The appointment of Dr. Baker as Dean of Students, and of Mr. Pitré as Dean of Freshmen, will be marked by an expansion of the duties of the office of the Dean of Students which has authority and responsibility for overseeing all aspects of student welfare and for the Institute's relationships with student government and recognized student activities, including athletics and fraternities.

By advising and counseling with individual students and with student groups, the Dean's Office seeks to promote fine morale, high standards of conduct, and the best possible conditions for personal development and educational achievement; and in concert with regis-

tration officers and other agencies of M.I.T. to co-ordinate academic with personal counseling.

Dr. Baker brings to his new post broad experience in the field of education and administration and a thorough knowledge of the interest and activities of young people. He has been a lecturer in sociology at Cleveland College of Western Reserve University and a trustee of Proctor Academy in Andover, N. H. and of the Hawken School for boys in Cleveland. His own interest in outdoor activities and sports led to his association with boys' camps early in his career, and he has been active in this field for many years. He directed the boys' camp of the Boston City Missionary Society at Camp Waldron, Meredith, N. H. from its beginning in 1929 until 1935, and has since been associated with other camps.

A native of Newtonville, Mass., Dr. Baker was educated at Phillips Exeter Academy, and at Dartmouth College from which he was graduated with the degree of Bachelor of Science in 1924, and then carried on graduate work at the Harvard Divinity School, completing his studies there in 1929. In 1938 Tufts College conferred on him the honorary degree of Doctor of Divinity.

From 1925 to 1929, Dr. Baker was assistant minister of the Mount Vernon Church in Boston and the next eight years was minister of the Westminster Church in Providence, R. I. From 1937 to 1942 he was vice-president of the American Unitarian Association, the central executive body of Unitarian churches in the United States and Canada with headquarters in Boston. Since 1942 he has been minister of the First Unitarian Church of Cleveland, which he leaves to take up his new duties on January 1.

As vice-president of the American Unitarian Association Dr. Baker was engaged in general administrative work and directed the fund-raising program and the publishing business for that denomination. For three years he directed the New England Unitarian radio hour. In Cleveland he edited and published a book of readings entitled *Think on These Things* of which 3,000,000 copies were distributed to men and women in the armed forces. During World War II, Dr. Baker was a member of the arbitration panel of the National Arbitration Association and a public panel member of the National War Labor Board.

In Cleveland, Dr. Baker took an active part in community affairs, serving on the board of trustees of the Welfare Federation of Cleveland and as a member of the board of directors of the Cleveland Church Federation. He was also a member of the board of trustees of the Cleveland Council on World Affairs. He has been chairman of the Better Housing Association of Cleveland and has been chairman of the board of directors of the National Consumers League for Fair Labor Standards. Dr. Baker was president of the Unitarian Ministerial Union from 1944 to this year and has been a member of the board of directors of the American Unitarian Association for several years. He is also a member of Delta Kappa Epsilon fraternity.

As Dean of Freshmen, Mr. Pitré assumes new and additional responsibilities for which his wide experience in dealing with incoming students particularly qualifies him. A native of Waterbury, Conn., he was graduated from Amherst College in 1919, and he is an honorary member of the M.I.T. Class of 1917. During 1919–1920 he was an instructor in chemistry at Phillips Andover Academy, and was also an instructor in chemistry at M.I.T. from 1920 to 1930.

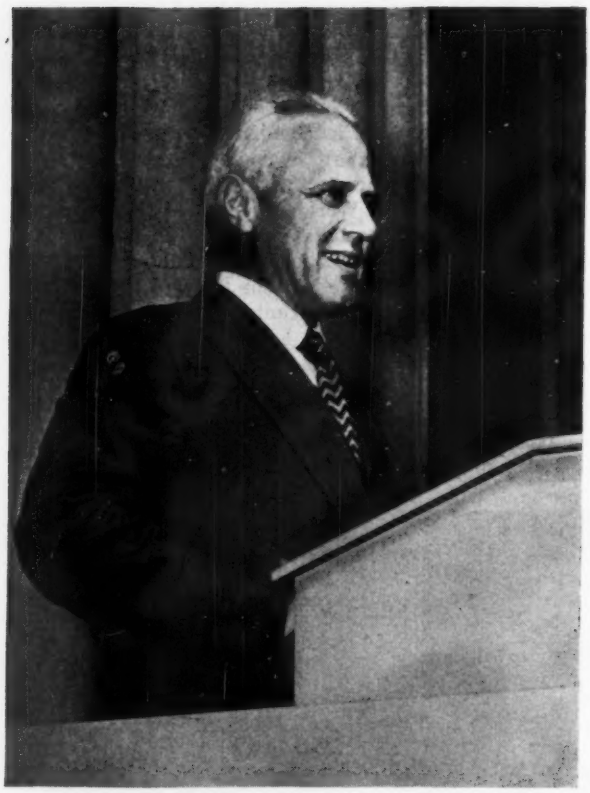
He was appointed assistant dean in 1930 and associate dean of students in 1939, and in each of these capacities he has been registration officer and chief adviser to freshman students for the past 17 years. He was the prime mover in originating and developing the current program of freshman scholarship awards, including the Regional Scholarships for which outstanding students have been nominated for scholarship aid by local alumni committees throughout the United States. He will succeed Dean Lobdell as chairman of the Faculty Committee on Undergraduate Scholarships.

Dean Pitré is a member of the American Chemical Society and also of the Delta Upsilon fraternity.

Associated with the Dean's Office for the past 17 years, Thomas P. Pitré takes up new responsibilities with his promotion to Dean of Freshmen.

Dean H. E. Lobdell, '17, unanimously selected for advancement, becomes Executive Vice-president of the Alumni Association of M.I.T.

As Dean of Students, Dr. Everett M. Baker, rich in educational and administrative experience, continues a career long devoted to young people.



The President Reports

CONCERN for the educational welfare of the largest group of students ever to enter M.I.T. permeated President Compton's annual report, delivered to the Corporation on October 9. The Administration is not only facing the difficult problem of providing educational facilities and opportunities of the highest order for the largest enrollment in the Institute's history under uncertain postwar conditions but it must also recognize many new requirements of a student body whose make-up is quite different from that which has heretofore roamed collegiate halls. Of the 5,000 students enrolled, more than 3,000 are war veterans, and about 1,000 are married. At a time when the nation's housing shortage is, it is hoped, at its crest the avalanche of married students poses a problem in housing facilities which, although difficult, is being satisfactorily solved. "No student has yet had to sleep on a park bench," stated Dr. Compton during a convocation in the Great Court on October 8.

The student body has 267 representatives from foreign countries. To a large extent (almost two-thirds) it is composed of war veterans who have seen all parts of the world and return to their studies with a seriousness of purpose and a sense of responsibility which are unusually high. President Compton's statement recognizing the characteristics of the new student body may also be regarded as the keynote of his report to the Corporation: "Obviously a student body of these general characteristics and of such maturity, capacity, and determination is a challenge to our best efforts."

Although it will probably be at least three or four years before the Institute can return to a status from which the traces of the war have been erased, the change from a wartime to a peacetime educational institution is making rapid strides. The transition is best reported in Dr. Compton's own words:

Fourteen months ago the Massachusetts Institute of Technology was a scientific arsenal, with a personnel of over 6,000 working on instrumentalities of warfare and 2,000 students largely training for warfare. In the period since V-J Day we have returned to our normal and primary function of education. The 6,000 employed personnel have diminished to 3,000 and the student body has increased to 5,000, the largest number of students ever enrolled at M.I.T. Fourteen months ago we were spending at the rate of $50,000,000 a year; we have now readjusted to a more manageable but still inflated annual expenditure of $11,000,000.

These figures are but ineloquent indices of the redeployment problems which have been met and, I am happy to report, largely solved. The Radiation Laboratory has been demobilized, its staff of 3,900 reduced to 15. Its great volume of purchase commitments, for months a matter of concern as it mounted million by million, is now almost completely liquidated, with a consequent reduction in liability and risk not to zero but to a point reassuringly near. Placement of wartime personnel has been largely accomplished. In fact, the demand for technical personnel has far exceeded our supply. The equipment used in the great war laboratories, the value running into many millions of dollars, the bulk running into uncounted tons, has been taken over by the Army and Navy, thus relieving the Institute of a burden which could easily have been a great handicap to reconversion. And, finally, the Institute space occupied by the war projects has been largely recaptured, and the temporary buildings, built primarily for war work, have been retained by the Institute to aid us in handling the postwar overload of students. With these major hurdles taken, we are in a much better position to meet the many other problems inherited from the war and inherent in the present period of readjustment.

For this rapid demobilization, credit is due many people — those who administered the projects and who planned for their liquidation with foresight and with a sense of fine responsibility to M.I.T.; those who, frequently at personal sacrifice, remained after the tumult and the shouting to assist in the liquidation; and the staff of our own Division of Industrial Coöperation, who have managed all contractual and business matters with prudence and vigilance.

The Institute Redeployed

The transition to a peacetime program has been more difficult because we are far from having returned to the scale of operations typical before the war. To use a budgetary index again, our current annual budget of $11,000,000 is three times our largest prewar budget. In 1939–1940 we had a total paid personnel, including staff and nonstaff, of 1,400. The current year finds us with 3,000, over twice as many. Total personnel at the Institute, including students, staff, and nonstaff, stands this fall at about 8,000, which is equal to our total personnel at the peak of the war program. Since the end of the war we have added 557 new persons to our instructional staff, of whom 57 have been Faculty appointments. To house the academic activities of this large group, we have found it necessary to occupy all the wartime buildings, with the result that we are using a plant — some of it temporary — greater by half a million square feet than that available before the war.

That these changes have thrown a great burden on both the administrative and teaching staff needs no comment, but one illustration will suffice. Before the war, about 1,000 new students were admitted to the Institute per year. Since July, 1945, we have been admitting approximately 1,000 students every four months, and over 2,300 students have been admitted for the fall term just begun. Thus there has been about a fivefold expansion in admission and registration activities, and these

have been carried on in circumstances of unusual pressure and complexity.

In terms of the prewar Institute we have therefore undergone a substantial expansion of our peacetime program. Part of this increase has come from new or continuing research financed by the Government, our research budget this year being of the order of $5,000,000. The most significant increase, however, has been in the size of our student body and in the resulting educational responsibility we have assumed. Our research activities are still important to the national defense and welfare, but they are now geared to industrial as well as governmental needs, and are integrated with our educational program. I wish in this report to give principal attention to this educational program and to those aspects of our operation affecting the welfare of our students generally. . . .

College Student — 1946 Model

The typical student was described as two to four years older than the pre-war student of the same class, having a poise and courtesy born of military experience. His objective is to obtain a first-class professional education as quickly as possible.

If the student of 1946 has been unable to find quarters in the dormitories, the Graduate House, the fraternity houses, or in the Westgate development for married students, or the barracks reconverted from one of the temporary war research buildings, he will have enlisted the aid of the Institute's Housing Bureau. Even then, he may be acutely aware of the national housing shortage. But, in respect to housing, the student at Technology is no worse off than some of the recent additions to the faculty or the administrative staff; relatively speaking, he may be much better cared for.

President Compton summarized the typical student of 1946 with the words: "Altogether you will gain the impression that he is able, personable, and sure of himself; that he has a well thought-out program for his education, is willing to work without stint to get ahead rapidly, and is competent and anxious to undertake larger tasks than a pre-war student of equivalent scholastic age." President Compton continued:

In this roughly sketched profile of the 1946 undergraduate, you have observed some of the special characteristics of the students now enrolled at the Institute. Taking the student body as a whole, we find that 3,000 of the 5,000 students are veterans and 3,700 are undergraduates, the remaining 1,300 being registered for postgraduate degrees. The undergraduates are almost evenly distributed among the four classes, with the senior class running slightly smaller.

The new students, both veteran and nonveteran, represent a degree of selection quite beyond that of any group ever before admitted. The 675 new freshmen who have just entered, for example, were chosen out of some 4,500 applications and many times that number of inquiries. About 2,300, or 80 per cent, of the undergraduates who were on leave of absence for war service are now back, and we expect ultimately to readmit nearly 100 per cent of these former students. Since the educational expenses of the veterans are financed largely by the Government, applicants have not been restricted by financial considerations. The students, therefore, come from all walks of life, and for the first time we have a student body for which ability, preparation, personality, and character have been the only requirements for admission.

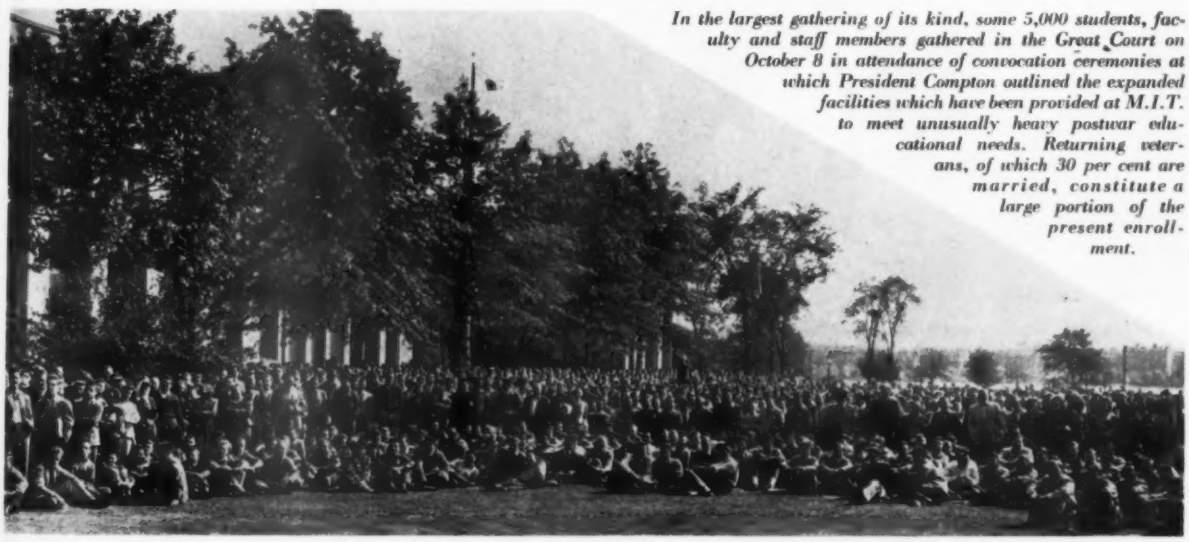
The postgraduate student enrollment represents an increase of about 550 over our pre-war Graduate School enrollment. The majority of these graduate students are being assisted by employment on research projects or by appointment as teaching assistants. Some of our departments, in fact, having found it necessary to increase their graduate student quotas in order to get the assistants needed to handle the undergraduate enrollment. Many of these graduate students have had extensive experience in war laboratories or in teaching and are therefore highly competent to undertake teaching or research of a high order while they study. . . .

Of the 5,000 students, there are 267 from foreign countries. Because of the overwhelming demand of American veterans, we have had to limit severely our acceptance of foreign students, although the demand from foreign countries has increased.

Standards of Scholarship

The recovery of high scholastic standards which, regrettably, could not always be maintained during the uncertainty of the war years, is being effected rapidly. Facilitated by the careful screening of all student applications by the Admissions Office, a big factor in this recovery is the maturity, serious purpose, and innate ability of the present student body. Dr. Compton said:

Another factor that has expedited the recovery of scholastic standards has been the rapid reassembly of our staff; we have had fortunately few losses in senior personnel. Moreover, we



In the largest gathering of its kind, some 5,000 students, faculty and staff members gathered in the Great Court on October 8 in attendance of convocation ceremonies at which President Compton outlined the expanded facilities which have been provided at M.I.T. to meet unusually heavy postwar educational needs. Returning veterans, of which 30 per cent are married, constitute a large portion of the present enrollment.

have been exceedingly fortunate in securing outstanding additions to our staff, both to fill vacancies and to provide for the larger student body. Taken either as a whole or department by department, and including the new and the old, I can say with pride and good conscience that this 1946 staff is unexcelled anywhere in the world in professional competence, reputation, loyalty, co-operation, and industry. Given the proper facilities it can without question meet the challenge . . .

The chairman of the Faculty has presented to the Faculty Council a proposal for a fundamental review of our present emergency program and, more importantly, a long-range study of our entire educational policies and procedures. This would be in line with past practice of periodically re-evaluating our educational objectives and methods . . .

If the proposal is adopted, as I trust that it will be, it will be the responsibility of this committee, with Faculty directive and advice, to formulate the scope and objectives of its study, but I think we can anticipate some of the matters which it will review: Do our admission requirements need revision, and can they be better co-ordinated with programs in the secondary schools? Are we too specialized in our undergraduate program in the upper two years, and is our Course system the most effective organization? Is it now possible to give a reputable and effective engineering education in four years? What should be the relative emphasis on undergraduate and postgraduate education, and how should they be related to each other? Have we swung too far in the direction of theory as distinct from practice, or have we not gone far enough? Have we yet allotted enough time for humanistic studies? Do we require too much routine and scheduled work, leaving our students too little time for self-development? No answers are presupposed to these questions, but the questions do indicate the comprehensiveness of the committee's assignment . . .

As the Faculty adjusts and tunes the delicate and complex organization of our undergraduate school, it is also looking out in new directions. The new Department of Food Technology launched its program during the year with financial assistance from six industrial companies, and the Department of Economics and Social Science organized a new undergraduate program in Economics and Engineering. The Department of Metallurgy, jointly with Chemical Engineering, undertook a new program in corrosion, and the Department of Mechanical Engineering transferred to Metallurgy its personnel and facilities in metal processing, where they are to provide the nucleus for a new program in mechanical metallurgy. As a result of opportunities developed during the war, we are organizing a new educational program in the field of gas turbines and jet propulsion, and are giving much greater emphasis to electronics and to nuclear science and engineering, all of which are certainly destined to occupy an important place in the technology of the future. Notable was the establishment of our first adequately endowed chair, the Sloan Professorship of Industrial Management. Under the generous endowment provided by Alfred P. Sloan, Jr., '95, this professorship will be supplemented by lectureships held by distinguished visiting lecturers from industry.

Administrative Personnel

In the administration of our educational program, we had one major change during the year. Dr. Edward L. Moreland, Dean of Engineering since 1938, asked to be relieved of this post as of July 1, 1946. Fortunately he agreed to continue to give part time to the Institute, and accepted appointment as Executive Vice-president to act as consultant to the President and Vice-president and to assume major responsibility in certain specified areas. To succeed him as Dean, we are happy in the appointment of Professor Thomas K. Sherwood, '24, of the Department of Chemical Engineering, who brings to the administration of the School of Engineering wide experience as an engineer and educator and intimate knowledge of the Institute . . .

I have spoken of the increase in our educational plant through additions made during the war. This added space has not only enabled us to take care of the great increase in the student body, but at the same time has both permitted and required a wholesale reallocation of space and renovation of equipment throughout the entire Institute plant. This general redistribution of space — the greatest since the Institute moved from Boston to Cambridge — together with the acquirement of the new buildings, is requiring an expenditure of $1,750,000. While this has been a very severe drain on the Institute's limited unrestricted capital resources, the Executive Com- (*Continued on page 110*)

The Class of 1896 marked its fifth decade since graduation from the Institute with a large reunion held at East Bay Lodge, Osterville, Mass. on June 7. From left to right (and back to front in some cases) standing: *Joseph Harrington, Charles E. Stamp, Edward S. Mansfield, Conrad H. Young, Charles W. Tucker, Perry B. Howard, Frank A. Howard, Edgar H. Barker, Daniel M. Bates, Mrs. E. M. Bragg, John Ashton, Mrs. Herman Curtis, Walter M. Stearns, Mrs. Conrad H. Young, Paul W. Litchfield, Charles P. Moat, Lewis B. Breed, Mrs. Walter S. Dodd, Lawrence K. Sager, Albert E. Cluett, Mrs. Samuel T. Smetters, James G. Melluish, Charles E Locke, Henry S. Baldwin, William P. Anderson, John A. Rockwell, Mrs. Henry D. Jackson, William T. Dorrance, Mrs. Lewis B. Breed, Myron E. Pierce, Mrs. Edward S. Mansfield, Elbridge C. Jacobs, William H. Clifford, Mrs. Charles W. Tucker, John Tilley, James M. Driscoll, Francis C. Hersey, J. Lloyd Wayne, 3d, Henry G. Grush, Henry R. Hedge, Myron L. Fuller, Samuel T. Smetters, Ralph C. Henry, and Frederick T. Rundlet.* Sitting, left to right, are: *E. M. Bragg, Frederick W. Damon, Elmer H. Robinson, Henry D. Jackson (deceased), Robert A. Davis, George S. Hewins, Samuel P. Hunt, Karl A. Pauly, Henry K. Sears, and William D. Coolidge.*

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Magnesium alloy body built by Purity Baking Co. from Revere sheet and standard shapes. Outside dimensions are 139¼" long, 80¼" wide, and 76" high. Weight of body, including interior tray racks to hold 2150 loaves of bread, is 1060 lbs. in magnesium compared to 2300 lbs. in steel.

ELIMINATE deadweight! That is the way to save gas, oil, tires and maintenance if you are hauling light, bulky loads like bread . . . and the way to increase payload if you are hauling heavy goods. The Purity Baking Co. saves 1240 pounds of deadload per truck with bodies built of Revere magnesium alloy sheet and extruded magnesium shapes!

The result: a cut in gasoline consumption of from 3 to 4 gallons on each typical delivery run of 125 miles, reduced wear and tear on tires and chassis, and trucks that are easier to handle. The fleet of the Purity Baking Co. averages 3,000,000 miles a year. When it is entirely equipped with these light-weight bodies, it is easy to see that gas savings alone will amount to a minimum of $1,000 a month.

Any operator could justifiably pay a premium price for such bodies. But Purity Baking Co., *without any previous experience in working with magnesium,* was able to build even the first unit at a cost which compares favorably with that of wood frame and steel panel bodies. And they report that the latest magnesium bodies they built actually cost less than the former wood and steel units! This is made possible by the standard magnesium structural shapes engineered and produced by Revere.

Readily available from Revere stock, these shapes plus Revere magnesium alloy sheet, make it possible for any builder to produce bodies of magnesium with the same ease as steel. No sheet metal forming is required. None but familiar methods of fabrication and assembly are involved . . . clamping, drilling, riveting. Yet the body designer has full latitude, and the finished units may be planned to fit any make of chassis.

For full details on this important Revere development, get in touch with the nearest Revere office. A Revere Technical Advisor will gladly consult with you on this and other applications of magnesium to your business.

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THE INSTITUTE GAZETTE

(*Continued from page 108*)

mittee has felt the expenditure warranted by the gain in educational efficiency thus made possible. For example, had we not modernized and enlarged our Chemistry laboratories, at a cost of $400,000, we would not be able to handle 900 students in each of the first two undergraduate years, compared with the 600 accommodated prior to the war. New laboratories for Physics, Mechanical Engineering, Electrical Engineering, Aeronautical Engineering, and other departments similarly have enlarged our capacity and provided better instructional facilities.

Charles Hayden Memorial Library

Every President's Report must review the past year and preview plans for the immediate future. It is fortunate when the report can include an announcement of a great step forward.

For years a library building fully adequate to the needs of the Institute has had top priority in our estimate of the desirability of new buildings. Plans have now been completed for a building facing the river front between the main educational buildings and Walker Memorial which will admirably fill this need and take the form of a memorial to a distinguished alumnus, the late Charles Hayden, '90.

Construction of this library building has been assured, I am happy to announce, by a gift of $2,200,000 received from the Charles Hayden Foundation through the generosity of Mr. Hayden's brother, J. Willard Hayden, and the cotrustees of the Foundation. This princely gift, the largest single gift received by the Institute since the Eastman benefactions, will cover a very large portion of the total cost of the building.

In planning this new library building we have conceived of it as serving a dual but consistent purpose. As the nucleus of our departmental library system and itself a great repository, it will provide the most serviceable collection possible of advanced research and teaching material in the scientific, engineering, and architectural disciplines to which the Institute is primarily devoted. In addition, however, it must serve the humanities program and the nonprofessional development of our students by offering them the maximum invitation to the many important fields of thought and inspiration outside our required curriculum. This concept recognizes that the humanistic responsibility of the Institute's Library is in some ways even more far reaching than that of the libraries of the great liberal arts institutions.

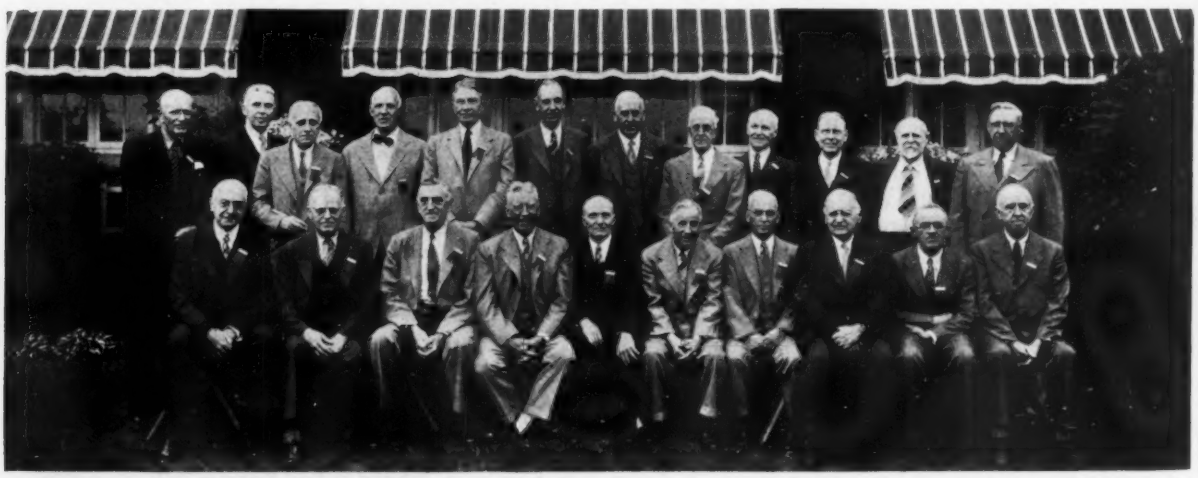
The Charles Hayden Memorial Library, then, will be a great deal more than a conventional library. It will house, for example, our departments in the social sciences and the humanities so that they will be contiguous to their libraries, which are in effect their laboratories. In addition to this formal implementation of the Institute's humanistic program, the new library will seek to facilitate the student's examination of various cultural heritages which cannot find a place in the formal curriculum. The already large collection of recorded music possessed by the Institute will be housed in carefully designed quarters in the new building as part of an audio-visual center which will make available all sorts of recorded sound as well as visual tools such as motion picture film. This center will be as modern as we know how to make it, will provide a variety of sizes of listening and viewing facilities, and, on the formal side, will increase the facilities for instruction in modern languages.

Other Building Projects

While the Charles Hayden Memorial Library is the principal addition to our educational plant which has been planned and financed, there are other projects of great importance. The new Gas Turbine Laboratory, made possible through grants from five industrial companies, is now under construction concurrently with the modernization and enlargement of the Sloan Automotive and Aircraft Engine Laboratory made possible through a generous additional gift from Alfred P. Sloan, Jr. Other new additions which are urgently needed and for which we are now seeking ways and means include a hydrodynamics laboratory and towing tank for our Department of Civil and Sanitary Engineering and our Department of Naval Architecture and Marine Engineering; an addition to our Metal Processing Laboratory to house a modernized and enlarged machine tool laboratory for our Department of Mechanical Engineering; a laboratory for the growing program in nuclear science and engineering; and a new building to house the Departments of Biology and Food Technology. . . .

Graduate School and Research

Although the scholastic and environmental needs of the undergraduate body took up the largest portion of President Compton's annual report, (*Continued on page 112*)



The Class of 1901, celebrating their 45th year as M.I.T. graduates, gathered at the New Ocean House, Swampscott, Mass. on June 7 and 8 for the reunion at which this photograph was taken. **From left to right, front row, are:** ***William E. Farnham, Asher L. Weil, Edward Seaver, Philip W. Moore, Robert L. Williams, Guy C. Peterson, Harry R. White, Willard W. Dow, Theodore H. Taft, and John Boyle, Jr.*** **Rear row, in reading order, are:** ***V. Frank Holmes, Mansfield Estabrook, Harry V. Allen, Robert M. Derby, Roger W. Wight, Ralph C. Robinson, George W. Allen, Edmond F. Brigham, Henry W. Chambers, J. Russell Putnam, Edward H. Davis, and Joseph D. Evans.***

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MAKERS OF FINE CLOTHES for Young Men and Men Who Never Grow Old

A gray, pink aftermath of dawn and the sportsman finds every nerve in his body leaping! The duck are heading for the decoys! To match the speed of their flight, split-second decisions must approach perfection . . . At Rogers Peet the same basic idea—the approach to perfection—is always uppermost in the mind of our Master Designer—perfection in fabric, style, tailoring and fit—perfection in clothes for young men, and men who never grow old.

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TREMONT ST. *at* BROMFIELD ST., BOSTON 8, MASS.

The right thing in everything men and boys wear

THE INSTITUTE GAZETTE

(*Continued from page 110*)

the Administration was also keenly aware of its responsibilities to graduate students, and to the needs of continuing the highest type of research work for government, industrial, and academic purposes. Said Dr. Compton:

The major attention given in this report to undergraduate instruction and student problems does not imply any lack of attention this past year to the Institute's Graduate School. With 1,300 students studying for advanced degrees and with vigorous research under way in all professional departments, the Graduate School is flourishing as never before. Its standards have never been higher or the quality and variety of research greater.

In relation to the Graduate School, let me direct attention briefly to three major trends which are beginning to play a very large role in our advanced program.

The first of these is the development of interdepartmental Centers of Research which co-ordinate the co-operative activities of various departments in certain very important fields of overlapping interest. While we call them "Centers of Research" because research is their predominant role, they are nevertheless destined to play a very important role in our educational program, especially at the senior and graduate student thesis levels. Their influence will also filter back into the co-operating departments to enliven and modernize their programs in the direction of the very latest technological developments.

These Centers of Research appear to be a highly satisfactory answer to a problem which has long confronted us and other institutions, namely, that of handling those interests which reach outside the traditional departmental boundary lines and require the co-operation of the specialists and points of view of various departments. Certain institutions have tried to meet this problem by setting up special institutes; others have set up new departments. Both of these solutions seem to us to be lacking in two desiderata, namely, the mobilizing of the interested personnel in various departments into a co-operative effort, while still recognizing each department's special interest in various aspects of the program, and the full co-ordination of the research with the educational program . . .

A second major new development in our programs of education and research is the greatly increased degree of interest and co-operation on the part of industry and the War and Navy departments. The work sponsored here by these outside agencies during the coming year involves a sum greater than the largest pre-war operating budget of the entire institution. From industry have come an increasing number of fellowships and substantial support of new teaching and research programs, several of which I have described earlier in this report.

The third feature of our educational program which I shall mention has to do with the greatly increased number of postgraduate students coming from the Army and Navy for training in certain specialties. For many years we have co-operated with the Navy to provide the postgraduate education of the naval constructors and, more recently, the combined program for naval constructors and naval engineers under the Bureau of Ships through an arrangement with the Postgraduate School at Annapolis. In addition to this, before the war we had a few special military students coming to study such subjects as torpedo design or fire control. Now, however, and again as a result of the recent war experience, both services are sending greatly increased numbers of selected young officers for postgraduate study in educational institutions. The demands on us for such educational assistance to Army and Navy have been

(*Concluded on page 114*)

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WE'VE added about 3,000,000 new telephones so far this year — more than twice as many as ever before.

That's one reason why local telephone calls are up 25,000,000 *a day* over last year. Long Distance calls have more than doubled since before the war.

We're doing some fast stepping to meet your needs, in spite of shortages of materials.

Best of all, service has remained good on most calls, despite the large increase in the use of the telephone. There are some delays, but we'll be taking care of all of them just as soon as additional equipment can be made and installed.

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Our extra quality sash cord, distinguished at a glance by our trade-mark, the colored spots. Especially well known as the most durable material for hanging windows, for which use it has been specified by architects for more than half a century.

THE INSTITUTE GAZETTE

(Concluded from page 112)

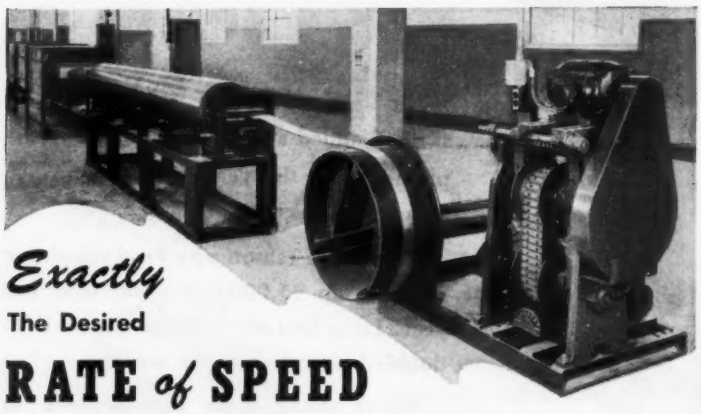
heavy and well reasoned, and we have had to limit the number admitted only because of the importance of retaining an appropriate share of opportunity for civilian graduate students to be trained for professional careers in industry or education.

The Financial Outlook

In August, I announced the Corporation's decision to increase the Institute's tuition from $600 per academic year to $700, the increase to take effect with the opening of the summer term in 1947. This decision to raise tuition, as you well know, was made reluctantly and only after rising costs made it unmistakably necessary. At the time the tuition was announced, we estimated that our unit expenses had risen 28 per cent since 1939–1940. They are still rising, and we must expect this year, before the higher tuition takes effect, to run a large deficit, amounting to several hundred thousand dollars.

Aside from the difficulties arising from this present period of inflation, the Institute has long-term financial problems which must be squarely faced. Our primary need is for capital funds, both to provide necessary and forward-looking new facilities, and to increase our endowment. This past year endowment income was only 24 per cent of our total income; in 1939–1940 it was 37 per cent. A large increase in the Institute's capital resources must be a major objective of the Administration and Corporation during the period just ahead. . . .

Internally the institution is sound and vigorous; externally its reputation is high. We should therefore face the future with confidence and a virile ambition for still further improvement and achievement.



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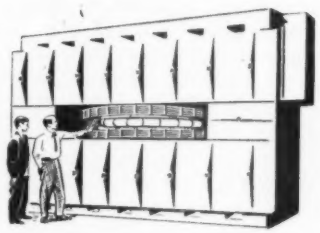

Creation of matter from energy—reverse of the process in the atomic bomb—is only one of the surprising things that can be accomplished with the aid of the 100,000,000-volt G-E Betatron. It can also:

- free particles of matter traveling at 99.99 per cent the speed of light,
- Produce the most powerful x-rays known to science,
- generate radiations heretofore available only in cosmic rays.

The Betatron is one of the big guns used by G.E. in finding nuclear facts that may be important in the production of atomic power.

GERM-KILLING LAMP

Lamps that disinfect the air through which their rays pass have been developed in the laboratories of the G-E Lamp Department.

Hospitals, military barracks, factories and schools use them to clean the air of bacteria.

Of particular importance to bakers, meat handlers and other food processors is the fact that G-E Germicidal Lamps also kill molds.

BOUNCER

In the G-E Research Laboratory, scientists turn up interesting new substances first and look for uses later.

Not so long ago they discovered "bouncing putty," a lively silicone by-product. But no one could find a use for it.

A sailor did. Hospitalized with an injured hand, he wanted something to knead in order to keep his fingers limber as they healed. Bouncing putty did the trick.

ELECTRONS AT WORK

New electronic devices worked out in G-E laboratories include:

- a canteen machine which grills hot dogs, hamburgers and cheese sandwiches in the heat of electronic oscillator tubes,
- a filter which cleans air by electrically charging motes of dust and smoke, then drawing them to magnetized plates,
- an electronic newspaper, to be delivered on radio waves soon in a dozen cities,
- a super-size 16-by-22-inch screen for G-E television receivers.

X-RAY BUSES

Four G-E built x-ray buses have been purchased by the State of Illinois to help in the fight against tuberculosis. These "x-ray rooms on wheels" will be used to conduct a statewide case-finding T.B. survey.

X-ray buses make it possible to provide such service without prohibitive cost because of special x-ray equipment. This equipment permits the use of miniature film and cuts chest survey cost by 88 per cent in comparison with the cost of standard, large-size x-ray films.

The State Health Departments in many other states are also equipped with these units and conduct x-ray surveys in co-operation with local medical groups, and T.B. associations.

TWO-WAY BLANKET

General Electric engineers have perfected an electric blanket with which different temperatures can be maintained on both sides of a bed. Complete with two sets of wiring and dual-temperatures control, it is possible for two people in the same bed to adjust the bed warmth to their individual needs.

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We are not satisfied merely to offer you magnets which come up to the proposed R.M.A. standards . . . this is our minimum requirement. A quality floor below which we refuse to go.

Nor are we satisfied that ordinary production and inspection methods offer you adequate quality protection . . . we *individually test* each Arnold magnet in a loud speaker structure before shipment.

Another "individual touch" which has contributed to winning industry-wide customer acceptance for Arnold magnets is our established minimum standard of 4,500,000 BHmax for Alnico V material.

Over five million Arnold loud speaker magnets of the R.M.A. type have been produced since V-J Day under these quality safeguards. Continued adherence to them assures you of long-lived, dependable product performance.

In the mass-production of magnets, the Arnold "individual touch" does make a difference. Let us give you the whole story.

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Specialists in the manufacture of ALNICO PERMANENT MAGNETS

ROCKETS IN BATTLE

(*Continued from page 100*)

rockets one such cruciform grain of proper size and length constituted the propelling charge, burning along its entire length inside a steel tube which carried the warhead in front and a set of exhaust nozzles in the rear. The fins, of which there were two types, were also attached to the rear end. Rockets of simpler mechanical construction used fins which were permanently fixed in one position. More elaborately constructed rockets used fins which folded back into recesses when the rocket was inside the launching tube and which spread as soon as the rocket was under way. Spinner rockets, employing the Hale principle, were also used, but the spin was imparted by means of slightly inclined exhaust nozzles.

When reading the following listing of American war rockets, one should keep in mind that some of them were hurry-up developments and makeshift arrangements. It should also be remembered that the whole array merely represents the beginning of a new evolution, and it should not be assumed that all these applications are more or less final. It is quite possible that both the portable rocket weapons and the airborne rockets may be replaced again by the new recoilless guns. Many of these ordnance rockets will not last, but they did their jobs well while they did last.

The tabulation is enlightening, to be sure, as a means of comparing the performance of different kinds of recently devised rockets, but when viewed as a means for providing historical perspective the list is even more revealing as an indication of the tremendous strides which have been made in processes of industrial manufacture. Even the experimental models of today's rockets are made by methods vastly more precise and speedy than were used for the production run of earlier rockets recorded in this article.

List of United States Ordnance Rockets World War II

Portable Rocket Weapons

Bazooka. Antitank rocket for direct fire, with portable launcher to be operated by a two-man team. Effective range, 200 yards. Warhead with penetrating shaped charge. Diameter of propelling rocket, 2.36 inches. The same rocket existed with a warhead filled with white phosphorus for smoke and incendiary action.

Super Bazooka. Improved version of the former. Dimensions same as original bazooka but fitted with a heavier propelling charge extending effective range to 700 yards.

Bazooka, 3.5-inch. Details of this rocket are still secret.

Airborne Rockets

Retro-rocket. Antisubmarine weapon fired backwards with velocities matching plane speeds so that the rocket fell vertically over the area where a submarine was known to be. There were three different rocket bodies to match the flying speeds of three airplane types used for submarine patrol. The head of this rocket was a modified version of the "mousetrap" rocket and carried 35 pounds of high explosives. Retro-rockets accounted for the last "probably sunk" German submarine of the war, on April 30, 1945.

Retro Float Light. Same as above, but fitted with flare.

3.5-inch Antisubmarine Rocket. Over-all length, 54½ inches; total weight, 54 pounds. Propelling charge consisted of one

(*Continued on page 118*)

RADIO FREQUENCY HEATING

gives you heat where you want it . . . as you want it

For many years, man has used *external heat* to harden, braze, solder, or anneal metals—to condition or otherwise treat such substances as rubber, textile fibers and the gluing of wood.

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Induction and dielectric heating have accomplished wonders in reducing production time and cost...controlling the rate and range of heating...improving quality and appearance of the product.

If you are interested in using this new production tool in your business, send for booklet B-3620 —or arrange for a showing of our new sound motion picture in full color: "Radio Frequency Heating."

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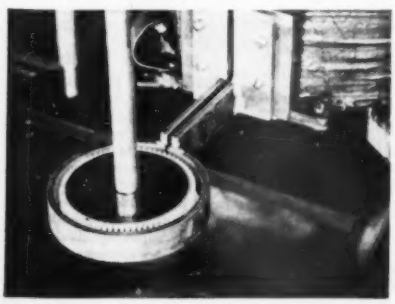
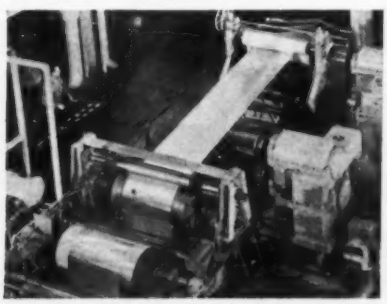


INDUCTION HEATING is ideal for hardening of gears (see above), contour hardening, brazing, soft soldering and annealing.



DURING THE WAR Westinghouse research engineers pioneered induction heating equipment for *reflowing tin* on electrolytic tin plate. Result *one* pound of tin now does the work of *three*.

DIELECTRIC HEATING has many advantages over conventional heating in bonding plywood (see above), molding plastic preforms, textile processing—and curing plastic laminates, rubber, etc.

ROCKETS IN BATTLE

(*Continued from page 116*)

8.5-pound grain. The head was solid steel, weighing 20 pounds.

3.5-inch Antisubmarine Rocket. Same rocket but fitted with 5-inch high-explosive warhead weighing 50 pounds.

4.5-inch Aircraft Rocket M-8. Total weight, 38 pounds, fitted with warhead containing five pounds of high explosives. At first with fixed fins, replaced later by folding fins. This rocket was fired from the well-publicized, three-tube clusters carried under the wings of various types of aircraft.

115-mm. Aircraft Rocket. Also known as the "super 4.5-inch." Over-all length, 6 feet; total weight, 103 pounds; weight of warhead, 40 pounds. Had four fixed fins. Longer range and more accuracy than the M-8 rocket. Two types of heads: one a semi-armor-piercing head; the other, a fragmentation casing holding 8.5 pounds of high explosives.

5-inch HVAR (high-velocity aircraft rocket) nicknamed "Holy Moses." Over-all length, 6 feet; total weight, 140 pounds. Propelled by a 24-pound grain. The rear end consisted of a disk with eight peripheral propulsion nozzles and a somewhat larger central nozzle closed by a metal plug which would hold at ordinary operational inside pressures but would be blown out if the pressure approached the safety limit. This type of rocket, introduced in combat in July, 1944, became the most used air-to-ground rocket of the United States armed forces.

"*Tiny Tim.*" Over-all length, 10 feet, 3 inches; diameter, 11¾ inches; total weight, 1,284 pounds. Warhead weighed 590 pounds and held 150 pounds of T.N.T. Propelling charge consisted of four grains with a total weight of 146 pounds. The rocket was launched by dropping it from the plane which carried it, with a lanyard attached to both plane and rocket. Rocket was ignited when lanyard was fully extended. First test in August, 1944; only combat use, Okinawa. "Unfortunately," as the official report phrases it, "the results could not be accurately ascertained. There were, it seems, so many things being thrown at the Japanese on Okinawa that it was impossible to distinguish the wreckage caused by 'Tiny Tim' from the general destruction."

Ground-to-Ground and Barrage Rockets

4.5-inch M-8. Same as listed above. Had range of 4,000 yards when used as a ground-to-ground weapon. The Navy used it with fixed fins as a barrage rocket and the Army with folding fins. Multiple launchers developed for this rocket were "Xylophone" (8 tubes, truck-mounted) and "Calliope" (60 tubes, mounted on turrets of General Sherman tanks).

4.5-inch Smoke Rocket. Same rocket, adapted for the laying of smoke screens. When carrying smoke composition head its range was 1,100 yards. Agent used was at first "FS Liquid Smoke" (a mixture of sulphurtrioxide and chlorosulphonic acid); later, white phosphorus. The 3.5-inch aircraft rocket also existed in a version adapted to smoke-screen laying.

7.2-inch Demolition Rocket. Warhead carried 32 pounds of high explosives. In appearance the rocket looked like a club. The Army launcher devised for it was nicknamed "Whiz Bang," and the 120-round Navy launcher for the same rocket (used from special rocket boats) was called "Woofus."

7.2-inch Chemical Rocket. Range up to 3,000 yards, was used for smoke composition and could have been used for poison gas. Each rocket carried 20 pounds of chemicals. The chemical 7.2-inch rocket had a special 24-round launcher nicknamed "Grand Slam."

4.5-inch Spinner Rocket M-16. Spin-stabilized rocket of same over-all weight as M-8, but with a range of 5,250 yards and a slightly heavier warhead. Launchers for this weapon were "Honeycomb" (24 tubes) and "Hornet's Nest" (60 tubes). A

(*Concluded on page 120*)

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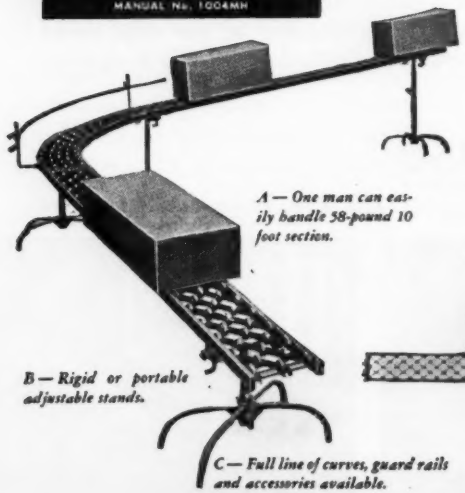

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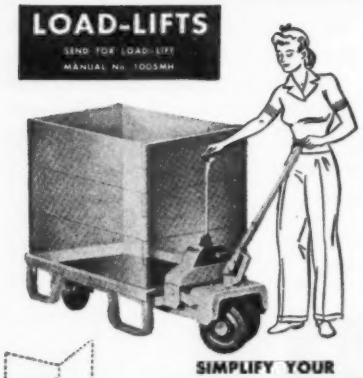

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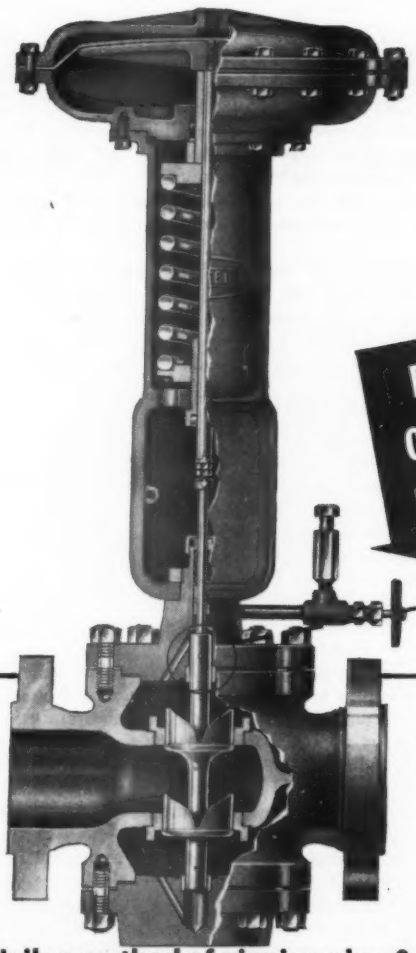
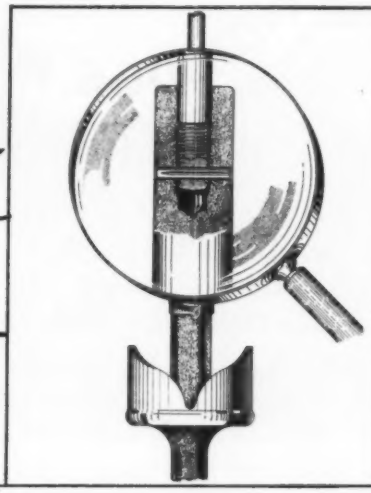
ATTENTION TO DETAIL

Pays Off in Control Valve Performance





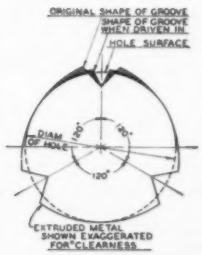
Note: One skirt of the valve plug is 90° out of position in relation to the other.

Mason-Neilan method of pinning plug & plug stem assures strongest possible assembly

The tee head construction used on some earlier control valves required clearance between the stem and plug to allow for bonnet and seat misalignment, permitting lost motion (vertical and rotary) which cannot be tolerated since the plug must respond to the slightest pressure change on the diaphragm.

The present Mason-Neilan threaded and pinned stem and plug construction does away with all toggles and free alignment joints, yet any tendency towards binding has been eliminated by pilot machining on the bonnet and blindhead and by holding all machine operations to close tolerances. The plug guide is drilled and tapped with a pilot section above the threads for accurate centering of the stem. The threaded joint provides the mechanical strength for holding the two parts together. The stem is locked into the plug by a special grooved pin which fits tightly at both ends in the guide as well as in the center through the stem.

Pins have three grooves extending from end to end, except for a short distance on one end which is the nominal diameter of the pin and serves as a pilot for driving.



In forming the grooves, a portion of the metal is displaced locally at the sides leaving a bulge of extruded metal along the edges of grooves and resulting in an expanded diameter. The action consists of forcing the elastic bulges partly back into the grooves when the pin is hammered or pressed into the drilled hole, thus forming an extremely tight fit against the hole wall.

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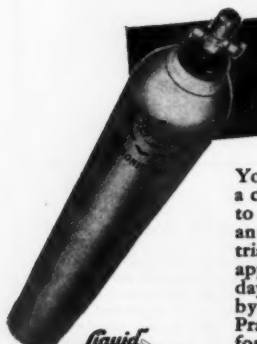

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ROCKETS IN BATTLE

(*Concluded from page 118*)

proximity fuse for the 4.5-inch spinner had been developed but was not actually used.

3.5-inch Spinner Rocket. Experimental only, not issued.

5-inch Spinner Rocket. Over-all length, about 30 inches; total weight, 50 pounds; range, between 700 and 1,000 yards, designed for penetrating flat-angle fire. Like the 115-millimeter aircraft rocket, the 5-inch spinner came with two types of warheads, one semi-armor-piercing, and one a general purpose head.

5-inch Spinner Barrage Rocket. Total weight, 50 pounds; over-all length, 32 inches; range, 5,000 yards. Two other spinner barrage rockets of the same caliber, but with ranges of 1,250 yards and 2,500 yards, respectively, were under development, but only the long-range type was used in action.

Special Applications

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Window Rocket. The 3.5-inch aircraft rocket adapted for the carrying of radar "window." Each head carried up to 75,000 pieces of aluminum foil, $\frac{3}{16}$ of an inch wide and from 1.5 to 16 inches long.

AA Target Rocket. The 3.5-inch rocket with large plywood fins, attaining a range of one mile and an average speed of 360 miles an hour. Used for training in antiaircraft gunnery.

Harpoon Rocket. A line-carrying rocket with a pointed head with four folding spades and two 4.5-inch rockets in tandem. The first rocket did the actual carrying; the second, ignited by a delay fuse, forced the pointed head deep into the ground. Pull on the line expanded the spades.

Snake. A long chain of metal plates, each 5 feet long and 5 inches wide. Total length, 100 feet; the front plate had an upsweep like a ski and mounting brackets for a 4.5-inch rocket. T.N.T. bricks were clamped to the plates; the whole was used to detonate a path through enemy mine fields.

POST-INDUSTRIALISM

(*Continued from page 103*)

without the necessary organs of collective association and responsible social control." [5] If this is not the heart of the protest against modern industrialism, it is certainly very close to it.

Aristotle believed that men came together in cities in order to live and that they remained in order to live the good life. The skepticism which is dampening the optimism of modern industrial peoples has to do with the problem of whether they can manage to exist under the conditions of industrialism as they have known it, much less to achieve the good life.

Whatever the good life may prove to be in modern technological culture, at least it must pivot around life itself. A civilization must achieve an organic ideology. So long as the machine remains the archetype of our existence, this prospect must remain dim, for at the expense of the development of human values, industrialism necessitates mechanical multiplication, power, expansion. As

(*Concluded on page 122*)

[5] Ref. Mumford, *op. cit.* page 239.

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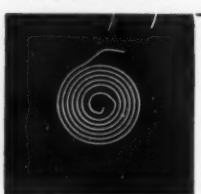
POST-INDUSTRIALISM

(*Concluded from page 120*)

the machine, with its economic and social congestion diminishes its mastery over human lives, a new frame of thought and action can emerge. A life-conditioned frame becomes possible with accent on individual human growth, norms, and inter-relationships. The new bio-technical community of man and nature, which post-industrialism brings to flower, swings the focus of collective attention from high concentration to a pattern of life which engages the depths of human experience. Industrialism has surely proved that concentration of physical power does not mean the same thing as the integration of human powers.

Basically, the problem of industrialism today is one of expectations. The technological conquest of the environment by industrialism is close to completion; some industrial countries have just about put the finishing touch to their industrial plant. Technologically, man can get whatever he wants. Practically, he does not. The problem becomes a simple one of showing the modern industrial man that he cannot get what he wants (which is contrary to the industrial pattern of motivations), that he should not fulfill his legitimate needs (which is cultural retrogression), or that he must be content with less than, or something quite different from, his justifiable desires (which is both industrially and culturally backward). The trouble with industrial people has been that they have not taken the time to find out just what kinds of experiences are possible and desirable, or how much opportunity there exists for the full development of human culture in a machine technology. A better, more wholesome, more highly developed cultural life might be expected to be their lot if industrial people would devote more attention to finding a solution for this interesting problems.

The post-industrial developments in machine technology — the gasoline motor, electric transmission, plastics, electronics, nucleonics — are hastening just such a consideration. The fact is, industrialism is decentralizing under our very eyes. A decentralizing industrialism makes possible the personalization of human relations in the resurrection of the small town, the small enterprise, the truly co-operative undertaking. Decentralized industrialism promises to make possible a personalized society in which whole human beings participate as significant persons, not as specialized functionaires, in the situations of collective living. Should this trend continue, the vicarious satisfactions of an anonymous industrial society will slowly give way to the direct, personal sharing in activities which, since long before industrialism, human beings have cherished.



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RADIOACTIVE BLOOD CELLS

(*Continued from page 94*)

sodium-citrate-dextrose solutions, namely, DeGowin's and Alsever's, were found to give adequate preservation for periods of from 12 to 15 days. The ratio of diluent to blood drawn was very high in these solutions, and yet this dilution did not seem particularly to aid preservation. Another high dilution solution with phosphate buffer, McGill solution, was found to be good for only 12 days. The addition of hydrochloric acid to the sodium-citrate-dextrose solution also gave preservation for 20 days. The best preservation was obtained with acid citrate dextrose commonly referred to as ACD. Two solutions were studied, both at a pH of 5.0, in one of which 120 cc. and in the other 75 cc. were used for the taking of 500 cc. of whole blood. These solutions gave satisfactory preservation for from 21 to 26 days.

No truly satisfactory solution to be added to packed red cells immediately after the removal of plasma ever was found. Ten per cent corn syrup permitted transfusion up to 10 days after drawing. Various phosphate buffered, citrate buffered, and bicarbonate buffered solutions permitted preservation for 10 to 16 days, but none of these solutions preserved resuspended red cells long enough to permit of their being shipped overseas with any guarantee that they could meet the 21-day period.

It was found, however, that if whole blood was taken in the acid-citrate-dextrose solution, promptly centrifuged and the plasma withdrawn, the cells could be stored in the packed state at optimal refrigeration temperatures, resuspended in a slightly hypertonic saline solution (1% NaCl or 0.85% NaCl plus 0.5% dextrose) just prior to transfusion, and could be transfused up to 21 and, in some instances, 25 days of storage, as if the cells had been stored as whole blood.

The acid-citrate-dextrose solution, therefore, was recommended by this group to the Committee on Medical Research of the Office of Scientific Research and Development, and by that office, to the Surgeon General's Office, for use in its overseas whole-blood program.

The determination of post-transfusion survival of the cells was one aspect of the study, but it was also of interest to learn something about the fate of those cells which were not retained within the recipient's blood stream. The method permitted of measuring both the quantity of these deteriorated cells and their rate of disappearance. It was observed that with well preserved blood, the rate of disappearance was extremely slow and usually complete within 24 hours. In the poorly preserved blood, the rate of disappearance was much more rapid, the bulk of the non-viable cells being destroyed within the first four to six hours after transfusion. This implied that a rather severe burden had been placed upon the reticulo-endothelial system of those patients who had received poorly preserved blood. The ability of the body to clear itself of plasma hemoglobin has been studied, and it was shown by calculation, on the basis of the radioactivity data, that until the preservation of a given transfusion fell below the 70 per cent level, the recipient's plasma hemoglobin level probably would not rise to dangerous levels. If only 70 per cent of the cells survived, the plasma hemoglobin level might temporarily exceed the renal threshold for hemoglobin, but the

(*Continued on page 126*)

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RADIOACTIVE BLOOD CELLS

(*Continued from page 124*)

mechanism was still efficient enough to clear the plasma of the hemoglobin within a relatively short period. If less than 70 per cent of the cells survived, plasma levels would undoubtedly be reached at which hemoglobin could not be promptly cleared from the blood stream. It was for this reason that the recommendation of a minimal acceptable preservation of at least 70 per cent of the transfused cells was made.

Technique of Refrigeration

Experiments also were conducted to determine the optimal range of refrigeration for blood in acid-citrate-dextrose, both during depot storage and aerial and land transportation. These experiments were conducted in collaboration with medical officers of the United States Navy and United States Army. In one experiment 10 bloods were taken in acid-citrate-dextrose and placed in a specially prepared, light-weight refrigerator to which was attached a recording thermometer. The thermal element of the instrument was in close proximity to the blood bottles. A dioxane indicator in the form of an L-shaped tube in which a small amount of dioxane, melting at 10°C., had been sealed, was secured to the neck of each bottle. Prior to fastening the indicator to the bottle the dioxane was frozen in the upper arm of the tube. The refrigerator held about 80 pounds of water ice, and was tightly sealed. This was flown from Boston to Oakland, California, and back, during the course of five days, during which time it was in flight about 70 hours. The refrigerator was re-iced at Oakland. On return to Boston, none of the dioxane indicators had melted. The recording obtained from the thermometer also indicated that, in all probability, the temperature inside the refrigerator had not exceeded 10°C. at any time during its travel. These 10 bloods were transfused into individual recipients from 9 to 26 days after they had been drawn. In all cases, survival was satisfactory; the lowest survival of any of the bloods being 76 per cent. This experiment was regarded as sufficient evidence of the safety of refrigerated aerial transportation by Navy medical authorities in planning their Pacific overseas whole-blood program.

In another experiment, five bloods in Alsever's solution (sodium-citrate saline-dextrose, citric acid, high dilution), and five bloods in ACD were flown to Paris and back. These bloods were not placed in a refrigerator but were simply wrapped in the original cartons in which the empty bottles had been received. Due to the exigencies of transatlantic flight during war in winter, a complete itinerary was not obtainable. However, the dioxane indicators had melted on return. Four of these bloods were transfused into individual recipients, and in no case was survival satisfactory. These bloods were from 19 to 20 days old, and survival was less than 30 per cent.

These two practical experiments illustrate forcibly the need for constant refrigeration to obtain adequate preservation of blood. This is particularly important in the matter of transportation and the handling incident to forwarding to battle areas. It was found that the optimal range of refrigeration lies between 4 and 10°C. and that 6° is probably preferable. It was also found that once deteriorative changes start in bloods stored above optimal

(*Continued on page 128*)

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RADIOACTIVE BLOOD CELLS

(*Continued from page 126*)

temperature, subsequent refrigeration at optimal temperature does not retard the initial rate of deterioration. Refrigeration from the time of drawing up to the time of administration is an absolute essential. In summary, then, it was found that whole blood taken in ACD may be safely transfused after refrigerated storage either in depot or during air, land, or sea transportation up to 21 days.

Military Uses of Whole Blood

The first use of whole blood in military surgery is replacement of lost blood due to wounds. The second use is the alleviation of a characteristic of the circulation in peripheral-vascular collapse, namely, the trapping out of active circulation within capillary beds of large amounts of red cells. This trapping leads to widespread anoxemia of tissue and all organs throughout the body, with eventual damage to the function of parenchymal cells. In addition to replacement of lost blood volume, successful therapy of shock depends upon the return of these trapped cells to active circulation, and the restoration to normal of capillary flow through all the organs. Probably far more serious than the known damage to the renal mechanism of the administration of badly preserved blood is the failure of such blood to accomplish its intended purpose, namely, restoration of circulation.

The reutilization of hemoglobin iron from non-viable cells was found to be about 60 per cent, even when large transfusions of poorly preserved cells were given. Since the utilization of iron by mouth is notoriously small, normally one to three per cent, the non-viable cells of these stored bloods served the useful purpose of supplying larger quantities of iron for red-cell regeneration than could ordinarily have been supplied. This had a favorable effect in hastening blood regeneration during convalescence.

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